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THE JOURNAL
OF THE
FRANKLIN INSTITUTE

DEVOTED TO

SCIENCE AND THE MECHANIC ARTS

EDITED BY

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DEVOTED TO SCIENCE AND THE MECHANIC ARTS

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FRANKLIN INSTITUTE

(*Popular Science Lecture delivered Monday evening, November 30, 1908.*)

OUR NATIONAL RESOURCES, THEIR CONSERVATION AND UTILIZATION.

BY

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The title "Our National Resources and their Utilization" will be understood as applying specifically to the United States, and chiefly to what may be termed Continental United States. Alaska and the insular possessions which have enlarged the national domain, each have possibilities worthy of a full presentation, but it has been considered advisable to confine the discussion this evening mainly to the portion of our country bounded on the north by Canada and the British Possessions, on the south by the Republic and the Gulf of Mexico, on the east and west respectively by the Atlantic and Pacific Oceans.

This area of 3,000,000 square miles of territory, varying in topography from 270 feet below ocean level in the Salton Sea to nearly 15,000 feet above this datum, includes enormous areas of productive arable lands, great river valleys, magnificent mountains, extensive deserts, some of which are being converted into fertile lands, a fair amount of forests, extensive plains on which

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[Note.—The Franklin Institute is not responsible for the statements and opinions advanced by contributors to the Journal.]

millions of cattle and sheep graze, and beneath the soil sources of present and prospective wealth in a variety of useful minerals and precious metals.

It shall be my endeavor to indicate some of the resources of the territory mentioned, and general features of their conservation and utilization. To discuss all in detail would make unnecessary demand on your patience, and those referred to will be treated as indicative of the balance.

The Press throughout the country has been practically unanimous in approval of the conference of Governors and other delegates, who by invitation of the President of the United States met in Washington in May, 1908, to consider the natural resources of this great country; and such endorsement has awakened public interest in a national problem of grave import, now being considered by a special commission.

The Washington conference and the studies of the Conservation Commission should, and it is sincerely hoped will, result in present and future good, but excerpts from the papers, discussions and statements credited to delegates which have been published, suggest that some of the enthusiasm for conservation, as it appears to have been understood, encourages conclusions scarcely warranted by facts.

This good movement must win by impressing its necessity and also its practicability upon the thinking people of the United States, whose support is to be gained by calm consideration. Oratorical pyrotechnics, theoretical discussions or dire prophecies which fail to stand criticism, will not secure conservation, and while great waste must be admitted, what is rated as Yankee ingenuity is to be credited with marked economies and progressive development.

The United States has moved with giant strides, and in material advancement "Uncle Sam" has worn the fabled "seven-league boots." Our spurts of speed have not been without damage, nor have our goals been gained except by sacrificing much of value. Some of this loss has been necessary—much of it the reverse, and it is not my purpose to condone waste, or apologize for practices which fail to secure the best results from the materials used, but to endeavor to discuss the problems broadly and equitably.

The introductory paragraphs of resolutions passed at the Washington conference may express the intention of this lecture.

"We, the Governors of the States and Territories of the United States of America in conference assembled, do hereby declare the conviction that the great prosperity of our country rests upon the abundant resources of the land chosen by our forefathers for their homes and where they laid the foundation of this great nation.

"We look upon these resources as a heritage to be made use of in establishing and promoting the comfort, prosperity and happiness of the American people, but not to be wasted, deteriorated or needlessly destroyed.

"We agree that our country's future is involved in this; that the great natural resources supply the material basis upon which our civilization must continue to depend, and upon which the perpetuity of the nation rests."

When requested to participate in this course the topic suggested was: "Conservation of Our Natural Resources," but in accepting the pleasant duty of addressing you, I asked that "Utilization" be added to the scope of the lecture, as these two must go hand in hand in our national development, for the locking up of a resource is not conservation and should be criticised as severely as waste.

According to our dictionaries, the definition of conservation is "the act of guarding or keeping with care; prevention from loss, decay, injury or violation, the keeping of a thing in a safe or entire state," and that of resource is "property that can be converted into supplies, available means or capabilities of any kind."

The conservation of resources is not therefore merely holding them in reserve for the future, but judicious practical utilization, *i.e.*, "turning them to profitable account or use, making them useful, or making use of them."

There have been given to us by nature resources of enormous volume and value the utilization of which has made this country great, and promise for it a bright future. Our duty is to use and also to conserve. In fact, utilization is not thorough except when associated with conservation, nor is conservation effective except as a consort of utilization. The proper employment of any natural resource takes into consideration future supplies and eliminates unnecessary waste, for we cannot lavishly use our natural resources and yet maintain a supply for posterity, particularly of such as are not reproductive. It may be practicable to maintain our farming and grazing lands; to provide for a continuous application of water for transportation, irrigation, supply or power by reforestation and by impounding reservoirs; or it may be possible by forest propagation and protection to maintain a supply of wood for future uses, for these are replenished, but we cannot renew the coal, the oil, the ores, or other minerals taken from the ground.

The conservation of natural resources must be considered in relation to a rapidly growing population, expanding over and developing wide areas of territory; their utilization must be profitable, and such as will best assist and not retard this development.

We are not excusable if in pursuit of business activities we neglect provision for those who may follow us, and no patriot desires to look forward to a decadence of the nation. But while appreciating a duty to posterity, we cannot load the present generation with inequitable burdens. Hence the determination of what is proper conservation and utilization of our national resources demands careful conscientious investigation by every lover of his country.

I recognize the value of enthusiasm in effecting any reform, and cheerfully credit those who may be classed as enthusiasts with patriotic motives, but I cannot endorse a late editorial which assigns the growing interest in conservation to the theorist, the doctrinaire, for conservation has been and is the constant endeavor of many practical men and women who make use of our resources.

It is not he who cries "Wolf! wolf!" but he that slays the wolf, who is the benefactor.

The abundance of our resources has not forced upon the United States the practical conservation necessary in other countries, but every invention which increases the possibilities of our country, every reduction in the unit of fuel or power required for a given amount of work, each useful purpose to which otherwise waste material is applied, every detail which lowers the cost of production, manufacture or transportation, is a step toward true conservation, and is to be credited with its share in the material progress of the nation, both present and prospective.

Thousands of active brains study economic problems, the solution of which adds to the material wealth of the country and the comfort of our people, by reducing the consumption of resources, lowering costs of production, or converting waste into valuable materials. All of these may be features of conservation and utilization, considered in connection with the permanence of the United States as a nation.

MINERALS.

Forests, water, soils and all minerals are considered natural resources, and the latter will receive first attention by some statistical data. Notwithstanding the freedom with which quantities and values are discussed in tens and hundreds of millions, few grasp the true meaning of such arrays of figures, and to assist in appreciating the production of the more important minerals some are reduced to daily averages, others being recorded by yearly outputs.

The United States produces *1,600,000* tons of *Coal* each working day, and of this amount Pennsylvania contributes nearly one-half.

The United States Geological Survey claims that with an average of 30 cars of coal to the train, and of 50 tons to the car, the number of trains required to transport the coal production of the United States in 1907 would be 320,300, the combined length of these trains extending two and two-thirds times around the world at the equator.

The *Iron Ores* mined in 1907 represent a daily output of *170,000* tons, more than one-half of which was won from the mines in Minnesota, a state which has been a producer for but 25 years.

In the same year

Lead and *Zinc* to the amount of *1,900* tons per day were obtained, mostly west of the Mississippi River.

Copper, chiefly from Arizona, Montana and Michigan, was produced at the rate of *1,400* tons daily.

And *Gold* and *Silver* valued at *$425,000* per day attest the volume of our metalliferous products.

Add to these a daily product of:

555,000 barrels of *Petroleum*,
170,000 barrels of *Cement*,
Nearly *100,000 barrels Salt.*

Also yearly outputs representing values of

$159,000,000 in *Clay Products*,
$53,000,000 in *Natural Gas*,
$84,000,000 in *Sand* and *Stone*,

$10,000,000 in *Phosphate Rock,*
$6,000,000 in *Slate,*
$5,000,000 in *Aluminium,*
$5,000,000 in *Sulphur,*
$5,000,000 in *Gypsum,*
$7,300,000 in *Mineral Waters,*
$2,800,000 in *Asphalt,*

and other minerals wrought on a liberal scale, and the magnitude of our mining industry may be appreciated.

The mineral production of the United States at points of distribution represented for the year 1907 a value in excess of two billion dollars—one third of this total being credited to Pennsylvania. We are using these resources at an enormous rate; to what extent are we conserving them?

SOIL PRODUCTS.

By preventing erosion, fertilizing our farms and caring for them and their products, our soil as a resource supplies quantities staggering in their magnitude. The figures for some of these for the year 1907 are:

Corn, 2,592 million bushels,

Wheat, Oats, Rye, Barley, Buckwheat and *Flaxseed,* an aggregate of 1,614 million bushels,

Potatoes, 298 million bushels,

Hay, 64 million tons,

Cotton, 11 million bales,

Sugar (cane and beet), 761,000 tons,

Tobacco, 349,000 tons,

Rice and other products, 19 million bushels.

Our soil supports 74 million *cattle,* 27 million *horses* and *mules* and over 112 million *sheep* and *swine.*

Irrigation projects estimated to cost $70,000,000 are now being carried forward, with the expectation of converting 2,000,000 acres of barren land into fertile fields, and interest lately has been directed to the reclamation by dikes and drainage of 126,000 square miles of swamp lands.

Water as a resource is applied everywhere, as a necessity for communities, manufactories, transportation and navigation. It is required in great quantities for domestic and municipal use, for crops and for all industries, and estimates of volume or value are difficult to formulate.

One authority gives the available water power of the country as 25,000,000 horse power, and states that out of the 16,000,000 horse power supplied one-fourth of it is produced by water power.

The forests furnish our timber and lumber necessary for homes, structures, railways, vessels, and other products; and statistics indicate that the people of the United States use 500 feet board measure per capita per annum, as against 60 feet average for European countries, the estimate of standing timber being 1,400,000 million feet, with an annual cut of 100,000 million feet. Our methods of construction and radical improvements in saw mills and taxation systems are responsible for this heavy inroad, but the waste in the use of lumber is enormous.

Air is a resource essential to life and to all processes of manufacture, but its service is materially lessened by treating it as a convenient medium for the removal of vapors and solid matter which menace the public health, disturb home comfort, and cause monetary damage to personal property.

Legislation for ameliorating what is termed the smoke nuisance and for the control of fumes, has had little effect in diminishing the undesirable features of vitiated air, but ultimately the cost of abating these must be offset against the damage which results, and the utilization of what is now wasted will increase.

We cannot throttle industries, or restrict transportation by drastic legislation, but we may demand such an appreciation of the rights of those who suffer illness, inconvenience or financial loss, as will limit objectionable features.

The air we breathe is not affected appreciably by the draughts upon it, and its plenitude encourages us to give it scant attention, but we are surely wasting a natural resource when we unnecessarily make it undesirable or offensive.

As the advance in the quantities produced has been unprecedented, and some of the materials enumerated have been practically made usable within late years, it is judicious and proper for each American to consider what the future demands will be; the possibility of meeting these; the extent to which curtailment is practicable and the opportunities of substitution.

At the Washington conference gentlemen recognized as authorities in specialties were invited to present various problems and made studied addresses, some of which, as reported, appear open to criticism, because they apparently neglect the relations of contemporaneous conditions.

Following a period of phenomenal activity it was natural that statistical comparisons be made with the year immediately preceding, but it may be inequitable to formulate opinions of prospective increase on records of the immediate past, to base deductions on the daily or annual statistical data, such as presented, unless we take into consideration applications of certain materials for specific uses, or recognize the advances and economies made.

Progress is not to be measured merely in quantities produced, but by the economical uses of our resources.

COAL.

In his address at the Washington conference the President made the statement, which was widely copied by the press, that the Nation's increase in the consumption of coal in 1907 over that of 1906 exceeded the total consumption of the year 1876, a comparison better understood when we consider that in 1876 coal was not so universally used for fuel as in 1907, and that many now productive fields were unknown or undeveloped in the Centennial year.

The population of the United States in 1876 approximated 45,000,000, and the Census Bureau estimates the population in 1907 as 85,500,000, and that of the year 1906 as 84,000,000; *i.e.* it was necessary in one year's time to supply 1,500,000 more people with coal for various uses. In 1876 there were 77,500 miles of railroad in the United States; in 1907 there were 324,000 miles; thus in the 30 years the railroad mileage had been augmented more than four times.

Other uses of fuel, such as the marvellous development of transportation on the Great Lakes and on the ocean, might be named, but the above are sufficient to indicate the greatly changed conditions.

In the Centennial year there were 1,868,961 tons of pig-iron made, of which 15 per cent. was produced with charcoal. In 1906-7 less than two per cent. of the pig-iron made was produced with vegetable fuel, and the pig-iron tonnage credited to 1907 was 25,800,000 tons, nearly thirteen times the output of 1876.

Since 1876 important industries have been largely developed or created, which consume fuel liberally. The application of electricity for power and light, now almost universal, was practically unknown in the Centennial year, and the greater portion is generated by the consumption of fuel in plants whose capacities are measured by tens of thousands horse power, one plant in Philadelphia approximating 50,000 horse power.

The growing use of electricity for light has however been met by advances in gas manufactured. Statistics of the production of illuminating gas in 1876 are not extant, the earliest annual production available being that for 1883, which was 27,877 million cubic feet. A calculation from proportionate growth estimates the quantity for 1876 as 22,000 million cubic feet, while for 1907 the figure of 102,140 million cubic feet is given, nearly five times the estimated production of 1876.

The Portland Cement Industry, which produces over 50,000,000 barrels per annum, is also a late development.

The output of Bessemer steel and its merchantable products has increased from 469,000 tons in 1876, and the open-hearth steel manufacture, which was then in its infancy, has grown to equal the Bessemer product, viz., 11,500,000 tons in 1907.

In 1876 Pennsylvania furnished less than 23 million tons of anthracite coal, in 1907 nearly 86 million tons, but in the latter year the amount of anthracite coal sold which was of sizes unmarketable in 1876 or which was recovered from waste dumps approximated the entire anthracite coal product of the Centennial year.

Although Pennsylvania is the largest producer of coal, the area of its coal fields places it eighth in rank among 33 states whose aggregate workable coal fields area is estimated at 327,000 square miles.

Other uses of fuel, such as the employment of gas producers and gas engines, the marvellous development of transportation on the Great Lakes and on the Ocean, might be named, but the above are sufficient to indicate the greatly changed conditions.

Reduced to a per capita coal consumption, each inhabitant of the United States used in 1876 1.17 tons per annum, and in 1907 5.62 tons per annum, a startling comparison, if we fail to appreciate the coal fields opened in the past 30 years, and the large areas unwrought which are known to hold liberal reserves of fuel.

Had President Roosevelt added to his remarks concerning coal, that, had we used fuel as wastefully in 1906 and 1907 as in 1876, the yearly annual increase for consumption would be more than double the production of 1876, the real advance of the country would have commanded attention without weakening the plea for conservation.

Coal has been the basis of the development of this country, but our best engines are calculated as obtaining but 10 to 15 per cent. of the energy in the coal which is converted into work. As further substitutes in part for coal, peat, petroleum, alcohol obtained from waste vegetable products, etc., may be factors.

Another speaker, in discussing the coal problem, stated that 25 per cent. of the coal in the developed mines is lost beyond recovery. Admitting this statement as true, and admitting deficiencies in present practice, the former losses do not prevail to an equal extent in present operations, where improved mining methods, recovery plants for reclaiming waste or beneficiating inferior material are multiplying.

With augmented population, increased railroad mileage, the establishment of all electric power transportation and lighting systems, larger pig-iron and steel outputs, new and diversified uses for fuel, the growth in its consumption, as presented, is not fairly comparable unless numerous economies introduced, and increased refinement of manufacture are considered.

While the text of the addresses at the Washington conference indicated that utilization was considered as embraced in conservation, the great mass of the people read only the salient features presented by press reports, which, unfortunately, held aloft the danger signal without giving credit to the progress made.

IRON ORE.

A successful iron master, basing conclusions upon a consumption of 1,200 pounds of iron ore per inhabitant last year, prophesied that in 30 years one-half of our supply of original iron ore will be exhausted, and that in a generation we must depend upon the leaner ores.

If these lean ores should be our reliance, which is not admitted, they will average about the same proportion of iron as the mineral fed to blast furnaces when Mr. Carnegie entered the iron business, from which he retired with a great fortune. He has seen the development of the Lake Superior iron ore region and its rapid growth, until 80 per cent. of domestic ores used come from this district and have displaced local ores, many of which lie dormant. He has seen the upbuilding of a magnificent iron and steel industry, resulting from the abundance and excellence of these ores, the district reaching the phenomenal output of 42,000,000 tons in 1907, with individual mines contributing one and one-half to two million tons each. But the output of 1907 may not be again reached for years; the curve of annual production of iron and steel, which in the last decade was approaching the vertical, may flatten, and we may give weight, such as they evidently deserve, to other domestic iron ore resources.

That leaner ores will be used no one doubts, in fact ores are now shipped from the Lake Superior region which for years were considered undesirable, but with improved mining, transportation and smelting methods, the actual cost of producing steel is not advanced, and it is probable that some leaner or less desirable ores could now be used advantageously and economically in place of ore brought from the Lake Superior region. While the draft upon the mines has been tremendous, apparently threatening exhaustion, new finds are constantly reported. Minnesota, the largest producer, has developed ore bodies beyond the Mississippi River, and in the older districts of the Lake Superior region new discoveries are not unusual.

The Lake Superior region is the most productive, but not the only source of domestic ore supply. The Southern states have reserves which will permit them to continue producing iron and steel in competition. Late developments in concentration in Northern New York demonstrate that a liberal supply of rich ore may be depended upon, and that state, as well as New Jersey and Pennsylvania, offer possibilities in iron ores, which, although requiring beneficiation, may be mined, treated and smelted, at expenditures that will make them competitors with Lake Superior ores.

As far as iron ore is concerned, the western portion of the

Continental United States has been but imperfectly explored, but in Wyoming, Colorado and New Mexico exploited deposits maintain an iron and steel industry approximating in capacity the product of Sweden, and show large reserves of available mineral.

The abundance of our minerals, the comparatively low cost at which they can be obtained and transported, and the high rate of labor which has prevailed in this country, have retarded the introduction of many economies, but in the iron industry wasteful methods have been modified, ores formerly refused are utilized, advances in metallurgy reduce the fuel and labor cost per ton of metal produced, and an effort to conserve resources is growing in appreciation.

Considered merely as an iron yielding material for a manufacturing industry, the possibilities of a foreign ore supply might be mentioned, but this discussion refers entirely to national resources.

For the past 10 years the average annual increase in pig-iron production has nearly equalled the production of the metal with mineral fuel in 1876, and as in the 30 years under consideration the railroad mileage of the country quadrupled, while the average business carried on per mile of road is greatly in excess of earlier years, the demands for iron and steel correspondingly augmented. If progress in other lines of industry is traced, similar results may be expected, and it is therefore not surprising to find that the statement made by the President could be amended, and that in late years we are annually augmenting the production, not only of coal but of other materials, at a rate greater than the entire country demanded in 1876.

With an advancing civilization, progressive industries, augmented wealth, and increased population, greater demands upon our mineral resources are to be expected. These are evidences of national development, and the problem presented to the people is not the use, but the abuse of the available resources. If the consumption of coal required per ton of freight or per passenger hauled per mile on the railroads, or if the amount necessary to make a ton of pig-iron or steel products, or to produce 100 horse power by prime movers, had been the same in 1907 as it was in 1876, the increase shown in that year over the previous one would be much greater than the total output in 1876.

In the absence of the advances in metallurgy and improvement in mechanical appliances, progress in iron and steel manufacture, in other industries and in transportation details would have been impossible. The country could not prosper as it does to-day if priçes of manufactured articles or costs of transportation were on the basis of 30 years ago.

Similar advances in other mineral products could supplement those of coal and iron, but we may pass to another resource.

FORESTS.

As an earnest forestry enthusiast, I do not minimize the destructive waste and reckless carelessness which have prevailed, and which are now far too evident in the condition of our forests, but it seems no more equitable to base conclusions on the past as to forestry than in the mineral products indicated.

Awakening public interest in forestry has been a self-imposed duty for more than a score of years, and while gratifying results are noted, it must be admitted that the value of trees and of forests is not generally appreciated. If the opposite were true the citizens of Philadelphia would revolt against the vandalism which last month permitted the sidewalk trees, struggling for existence between asphalt driveway and pavement, to be maimed and damaged by the erection of temporary stands from which to view street parades. Residents of suburban communities would protest against the destruction of rows of valuable trees to straighten sidewalks or make room for hedges, and the people of the state would be interested in forest fire legislation, and urge a basis of taxation which would not discourage the maintenance of forests by land owners.

The carelessness, which causes most of our forest fires, and the recklessness with which trees are felled or damaged to accommodate overhead wires or other improvements, are additional instances of inadequate appreciation. But a steady advance has been made in two decades, and no state equals our own in progressive forestry.

Substitutions for wood, which have been necessitated, may be expected to increase, and investigations carried on by railroad companies and steel industries will ultimately develop satisfactory substitutes for the timber tie, but some progressive roads have established nurseries to grow trees for ties. Steel buildings, cars and bridges and structures into which reinforced concrete enter, aid in reducing the demands on the forests, but increasing population and diversified industries necessitate economies in the uses of wood.

The United States Government, with wise foresight, has set aside large areas of forest reserves, aggregating a total of 165,000,000 acres. Nine states have supplemented this with reservations amounting to 2,000,000 acres, and other additions will be made by national, state, corporation and private reserves. The proper care of these will extend the limits of our wood supply, and if the Government and various states add to these areas and protect and utilize them, the predicted timber famine will be further removed.

We may be proud of Pennsylvania's record in forest preservation, especially for the decade closing with the present year, during which it has accumulated, by actual purchase, more than three-quarters of a million acres of land, which are being administered in a practical conservative manner. These three-quarters of a million acres have cost the state, including contingencies and other expenses, $2,345,400, or about $3.00 per acre.

The Forest Academy, maintained by the state, is a unique institution, there being no other of this class, and its advantages will be increased from year to year. In addition to the Forest Academy, the State College has established a Forestry Department, and the Summer Forest School of Yale University is located at Milford, while some High Schools give instruction in forestry, and Arbor Day celebrations by Proclamation of the Governor each spring, and by the announcement of the Superintendent of Public Instruction each fall, show that forest education is not neglected.

The establishment of sanitoria for the care of citizens suffering from tuberculosis has also developed a valuable feature of the forest reserves, and it may be expected that under the care of the Department of Health, which received for this purpose an initial appropriation of $600,000, the number and efficiency of these will increase.

We shall soon utilize much of our forest waste, and while we may not follow the economic methods of Central Europe, where small wood is fagoted for fuel, or of Sweden, where saw-dust and lumber refuse are converted into gas for producing steel by the open-hearth process, we may anticipate more liberal application of the waste resulting in felling timber and producing lumber.

True conservation of our forests is not to follow the lead of New York, whose extensive reserves, the largest of any state, are held so as to interdict any use, but is better represented by the forest policy of Pennsylvania, which gives power to its Forestry Reservation Commission to administer state forests so that trees which may be cut when matured are replaced by forests which are propagated and protected.

While lumbering operations, bark peeling, turpentine tapping, charcoal burning, the preparation of logs for wood pulp manufacture, and other drains upon the forests have been and are wasteful, they have furnished products of value; and in some localities efforts at reforestation have been made. In fact some of the most valuable tracts of Pennsylvania forest reserves are the wooded lands maintained by blast furnaces, which produced iron with charcoal.

Probably more of our forests have been wasted by fire than by all other means, and fire often makes tree reproduction difficult, if not impossible. The urban population represents a large percentage of the total, and those who live in cities and large communities have little appreciation of the terrific destruction caused by forest fires, until the press records disasters such as ravaged portions of our own country and Canada a short time since, laying towns in ashes and causing loss of life and property, or until our Forest Commission reports that in 1908 forest fires burned over 850,000 acres in Pennsylvania. We fail to realize that a forest fire is not merely a monetary loss to the land owner, but that it depletes a resource, which, although capable of reproduction under judicious management, requires at least a generation for this process.

By protecting our forests from destruction, by making provision for combating fire, and by visiting punishment upon those responsible, we may minimize the damage from this source. But true conservation also demands care in the utilization of our forests, continued efforts toward reforestation, and the adjustment of taxation upon wooded lands so that their maintenance will be encouraged.

The prophecy of timber shortage, made by the head of a great railroad system which had in its construction and maintenance caused the denudation of vast forested areas, is to be viewed in the light of the forest reserves established, the legislation concerning the protection of these and the maintenance of tree nurseries and the improvement cuttings which are being carried forward.

WATER.

Water is a natural resource, the proper conservation and economical utilization of which will add greatly to the wealth of the nation, but except in the arid and semi-arid sections of the country its importance is not appreciated, until drought limits the supply or freshets damage property. The year 1908 has been remarkable for the duration of drought and severity of freshets in Pennsylvania, and public attention has been directed to the necessity of ameliorating these extreme conditions to the extent which man is able to combat natural forces.

It is not assumed that floods or droughts can be prevented. A proper proportion of forest cover maintained and protected on various drainage basins will hold back much of the storm waters in a saturated humus formed from the accumulated leaf waste of years, and give this off slowly, sustaining stream flow when the rainfall is insufficient. But the wood's floor or humus does not and cannot absorb the entire precipitation of heavy or protracted storms and rapid melting of snow or ice, and at such times an uncontrollable run-off of temporary duration results.

In this state extreme flood in many streams is 1,000 times the volume of the minimum low water discharge, and the problem of equalizing stream flow is a difficult one.

Reservoirs of large capacity are of marked service in steadying stream flow by impounding a part of storm water, and so delivering this as to increase the discharge when insufficient rain reduces the streams below normal limits. But the expense of such structures is generally great, and their capacity must be gauged by an outlay warranted by the results attained. Storage must also be based upon average years, for the construction of impounding reservoirs which are only filled in times of abnormal rainfall can seldom be approved. Consequently, the judicious maintenance and distribution of forest cover and the creation of storage reservoirs ameliorate, but will not necessarily prevent the damage or inconvenience from freshet or drought.

Storage for public supply seldom approximates that required for irrigation, for power or for transportation, as the conservation of sufficient volumes to maintain a power plant at a capacity equated to normal stream flow, or afford navigation during droughts, or nourish otherwise arid soil, requires enormous amounts of water held in reserve.

The steadying of stream flow may tide over many times of limited discharge, and materially diminish the frequency and intensity of floods, making our brooks, creeks and rivers more available as means of water supplies, of greater value for irrigation problems or for the development of water power, and improving such portions of the streams as are navigable, or which can be made so, for the soil waste resulting from torrential or continued excessive rainfall finds lodgement in stream beds, thus doing double damage.

Conservation of water as a resource includes the development of our waterways as transportation media, and it is questionable whether the nation has not suffered by the anxiety to develop railways while neglecting river improvements and by permitting existing canals to be abandoned.

While the national, state and municipal governments have made liberal appropriations for harbor and river improvements, the aggregate outlay for what may be termed Continental America is not great when considered as affecting an area of 3,000,000 square miles, with 4,000 miles of coast washed by two oceans and the Gulf of Mexico, and a lake system 1,400 miles in length.

We are far from reaping full benefit from our 25,000 miles of navigable streams, and obtain no value from equal mileage subject to possible improvement, for in the United States there are but 2,000 miles of canal.

Great Britain maintains 4,000 miles of canals and improved rivers.

France has 3,600 miles of canals and 4,000 miles of navigable rivers.

Germany maintains canals whose total length exceeds those of the United States.

The possibilities of canalizing rivers, improving their depth and cross sections, constructing coastal deep waterways, are all features of conservation and utilization of water as a natural resource.

We have a number of hydraulic power installations, and important irrigation problems have been met, but we are far from utilizing the possibilities of our streams.

To give some idea of the potential value of the water as power, we may consider our own state with an area of 45,126 square miles, and a topography ranging from sea level to 2,800 feet above that datum, the average elevation probably approximating 1,000 feet. On this area there is an average annual rainfall of about 42 inches. Assuming that with a fair amount of impounding capacity, one-half of this rainfall could be utilized for developing power, and that the topographical conditions admit of the utilization of one-half the averaged elevation upon sea level for water power improvements, the precipitation upon the area of Pennsylvania during a year of average rainfall, would be sufficient to develop with good water-wheels 3,000,000 horse power continuously, or if this water were applied to hydro-electric units of approved construction, 2,000,000 kilowatts continuously.

This merely indicates theoretical possibilities, but although apparently liberal allowances have been made in the proportion of rainfall available and in the fall utilized, other conditions interfere with practical development. The construction of railroads has generally followed watercourses; communities have grown up and industries have been built along the banks of streams, and often the best arable lands are in the meadows adjacent to stream beds; thus apparently possible sites for water-power improvements are not available, except at extravagant outlay for damages, and by overcoming serious opposition from vested rights. In the mountainous section the fall per mile is greater, but the volume of the stream is less than in the lower reaches, and numerous locations, which at first sight appear desirable, will not offer sufficient power to warrant an installation of equipment and the conveyance of the current generated to distant points.

The application of water for power does not consume, but merely utilizes this fluid in transit, but the necessity on most streams of providing storage to equalize the flow, and the diminished fuel consumption by reason of the power produced, place the improvement of water powers among the features of conservation.

Our water-supply systems are extensive, a number of them exceptionally good, and improvements are constantly being made, but during the past months many communities have suffered from scanty supply, which emphasizes the necessity of conservation. Sewage disposal and garbage utilization plants are also increasing.

A feature of practical conservation of water for municipal use is the leakage in reservoirs and distribution systems. The pipe lines in the streets of Philadelphia have probably 700,000 joints and over a quarter of a million house and factory connections, and perfection is not to be expected. The millions of joints, faucets, etc., in the buildings assist to swell the opportunities for leakage, and true conservation suggests that a municipality's duty is to maintain its pumps, reservoirs and distributing system as free from leaks as possible, and for the manufacturer or householder to prevent all loss of water practicable.

With these deficiencies corrected as far as can be done, and unnecessary loss prevented, it may not be necessary to estimate for water supplies based upon a daily consumption of 250 to 300 gallons per inhabitant.

The proper conservation and utilization of water also prohibits its unnecessary befoulment, and suggests that we get away from the notion that streams are to be the media of removing all that we consider undesirable. We are not justified in fouling streams because water may be artificially purified by various filtration processes.

I am not sufficiently optimistic to anticipate that mining and manufacturing industries will retain or utilize all refuse and waste, or that all sewage will be disposed; but I believe that conditions which are now detrimental may be much improved without submitting important industries to serious hardships, or interfering with the development of communities.

CONCLUSIONS.

Our minerals as natural resources must be won from the earth by mines and through shafts, drifts and tunnels, or by enormous excavations, bringing into play the best efforts of a progressive educated people.

To win a few ounces of gold tons of material must be handled, and other metals are found in such chemical composition that intricate treatment, or beneficiation, is necessary to make them serviceable.

Coal is a natural resource, but must be dug from deep mines, passed through breakers and washers, and a large portion converted into coke, for use in smelting iron ores to produce the pig-iron which has done so much to place the United States in a prominent position among the nations of the world.

Forests are natural resources, but their utilization demands the axe, saw and mill, the handicraft of the carpenter to fabricate the wood into usable form, and the intelligent foresight and care of the forester.

Water is a natural resource, as springs, rivulets, brooks, creeks, rivers or oceans. In the small volumes it supplies a necessity for our existence, in larger streams it becomes a medium of transportation, and as a source for power or for irrigation volume and fall are considered. Water can be used as a means of transportation only so far as there are no obstructions for vessels, but where this is extended, man's services are required in dredging channels, constructing jetties, building canals, locks, and making navigation safe by break-waters and light-houses.

Water may be free to all, but to supply a community, or irrigate land, or develop hydraulic power, man must build dams, ditches, reservoirs, lay pipe-lines or conduits, and erect machinery; much of our engineering knowledge and ability being devoted to a continual contest with water, either in combating it or controlling it.

Conservation of natural resources will result from calm consideration of their extent, character and possibilities, for the variety and amount at our command are blessings to be appreciated by utilizing and conserving them, and we deserve to fail as a nation if we are careless concerning these features.

But true conservation is not advanced by scare heads announcing the exhaustion of our minerals, the length of time our timber will last, the depletion of our water resources, the destruction of our soils, and like dire prognostications. It is more patriotic to recognize that our national development is the result of using the resources with which God has endowed us, and to treat them as a trust, administered so that we and those who follow us will get the most good from them.

The man who plants trees is a better friend of forestry than one whose enthusiasm consists of quoting "Woodman, spare that tree."

He who converts any waste product to a useful purpose is a better conservator of resources than one who, viewing merely the quantities used, prophesies national decline.

Conservation is now popular; to have it continue so we need to study our resources as aids to progress and means for future prosperity. It must be recognized as a serious problem for the people and not as a fad of a bureaucratic coterie. The active coöperation of the brain and brawn of the country is essential to secure the conservation and utilization of our national resources, thus maintaining and perpetuating the United States as foremost among nations.

CEMENT AS A SUBSTITUTE FOR WOOD.

PROBABLE EFFECT ON LUMBER PRICES.

The relation between the increasing use of cement and the diminishing timber supply in the United States has been the subject of some interesting correspondence between the Geological Survey and the Forest Service at Washington. In a letter to the Forester, the Director of the Survey took occasion to quote from a statement of a large Philadelphia firm to the effect that it would be difficult to estimate what the additional drain on the lumber supply would have been during the last few years had not cement come into such general use. The Forester replied in part as follows:

"The Forest Service is watching with a great deal of interest the increasing use of cement and other substitutes for wood. They are undoubtedly having some influence on the price of lumber, though I do not think that up to the present time they have greatly retarded the advance in lumber prices. The fact is that our industrial progress has been so great that our requirements for every kind of structural material have increased tremendously. We are using at the present time more lumber per capita than ever before, and probably twice as much per capita as we did fifty years ago. The conclusion cannot be escaped, therefore, that in the future we must depend more than in the past on other materials than wood for certain purposes at least. As to the increase that will take place in the production of cement, my impression is that this will be very great."

If the increase in the use of cement in the United States in past years is to be regarded as any index to its future use, the conclusions of the Forester are well founded. The statistics of the production of minerals show that our output of cement has more than doubled in the last five years, and it is well known that its use is being very widely extended. This is due to two conditions: In the first place, excellent cement materials are common in almost all sections of the country; in the second place, reinforced concrete for heavy building material is receiving increased favor among engineers, while in the country regions large amounts of cement are being used for building blocks for smaller structures. Reports received by the Survey during the six years from 1902 to 1907 show that the production of cement in the United States has increased from 25,000,000 barrels, valued at approximately $25,000,000, to 51,000,000 barrels, valued at $55,000,000, the annual statistics showing a steady increase in production with some slight fluctuations in price.

FRANKLIN INSTITUTE

(Stated Meeting held Wednesday, November 18, 1908.)

THE DEVELOPMENT OF THE ELECTRIC PIANO PLAYER.

BY
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It is said that every good medical essay begins with Aristotle. I cannot with my subject to-night go back so far, but I go almost to the beginning of the electrical art.

The wonderful results obtained by the great masters of the art of piano playing ordinarily serve to disguise from us the simplicity of the means employed. This mechanical simplicity at an early date directed the attention of mechanicians towards seeking a substitute for the pianist's fingers. When a piano key is struck its hammer is thrown against the corresponding string, from which it immediately rebounds part way, and in this mid position it is caught and held until the key is released. The depression of the key simultaneously lifts the damper from the string. Both hammer and damper are therefore clear of the string while it is sounding. Nothing can be done to the key before the hammer is thrown, or after it is thrown and before the damper is returned, that can at all alter the tone produced. In any given instrument the pianist controls manually only the velocity with which the hammer strikes the string, and the return of the damper. The ordinary pedals add no new feature, they merely add to the ease of control. The wonderful art of piano playing is therefore built up by varying two simple elements.

Froment appears to have attacked the problem as early as 1850, but I have not been able to procure any accurate account of his work. In 1861 a patent for an electric player was taken out in Württemberg by Andre. In 1867 the celebrated mechanician Hipp exhibited an electrically operated piano which is worthy of some attention. It may be considered as the foundation of the work of the present day and indeed in some respects it is in advance of much of the subsequent work. The Hipp apparatus consisted of two parts, a transmitter and a receiver. The latter consisted of a series of electro-magnets with armatures pivoted so as to swing towards and across the poles, and having the armatures connected by wooden rods with the jacks of the piano action. The transmitter employed a roll of perforated cardboard or cloth, similar apparently to the music rolls now so familiar, which was drawn by means of clock-work from one wooden roller to another. On its course it passed over a metallic roller and under a comb consisting of wires properly spaced and held in an insulating frame. The roller and the wires of the comb formed terminals of electric circuits including the magnets in the piano. The method of action is obvious. It is necessary to add that expression was controlled by the insertion of resistances in the common return. That he chose a type of magnet whose action could be modified in this manner is one of the evidences of Hipp's knowledge and careful work.

Another Swiss, Spiess, exhibited an electric player in Paris the following year, 1868. So far as the description goes this player seems to be substantially the same as Hipp's. We are more fortunate, however, in that we possess a contemporary statement as to the results obtained. The clearness and distinctness in rapid passages are the subject of special praise. It may be of interest to add that Hipp operated with ten Bunsen cells and Spiess with thirty-six Daniell. To a considerable extent Hipp and Spiess must be regarded as being too far in advance of their time. The lack of a cheap supply of electric energy and the relatively small number of pianos in use would have precluded commercial success in any event.

At much about the same time as Hipp and Spiess, Prof. J. B. Webb and Mr. Oberlin Smith were at work on the problem in this country. They sought to replace the perforated tape by one having the notes printed in metallic ink, and they tried also a conducting tape with the notes printed in insulating ink. Other work proved more attractive to both inventors and they abandoned the piano player in an unfinished condition.

In the late seventies and early eighties William F. and Henry Schmoele of Philadelphia took out a number of patents relating to piano players. One of the patents described a music roll with the notes printed in metallic ink. The Schmoeles, who had on the whole a very clear idea of what a piano player ought to do, seem to have been deterred from the use of a straight electric action by the cost and unreliability of the supply of electricity at that time. They fell back on an electro-pneumatic action similar to that employed in playing organs from a distance, or, to compare their apparatus with what has now become more familiar, it resembled the present-day pneumatic action with the primary pneumatic replaced by an electric action.

At the electrical exposition of 1881 in Paris, Carpentier, the well-known instrument maker, exhibited a piano-playing apparatus which he called a repeating Melograph. The name Melograph had already been applied to an instrument exhibited at Vienna in 1873 designed to record piano playing. The complete Carpentier instrument was intended to cut a record of a composition played at the keyboard in the ordinary manner, and then to use this record as the music roll in the reproducer. In reproduction, which alone concerns us, Carpentier introduced a new idea. A shaft revolving at a fixed speed was placed under the keyboard. A number of brake shoes, corresponding to the keys to be operated and linked to them, were placed contiguous to the shaft, and pivoted so that a slight motion would apply them to it. When so applied the friction developed would pull down the piano keys with a force dependent on the speed of the shaft. The magnets controlled by the music roll instead of operating the piano action had only to throw the brake shoes against the rotating shaft. In this way it became possible to use smaller magnets and to economize in the use of electric energy, but unfortunately at the loss of control of expression.

Some dozen or more years later Carpentier's scheme was taken up by an American inventor, Mr. G. H. Davis, and embodied in a commercial machine. In the machine as now constructed Carpentier's cylindrical shaft has been replaced by one in the shape of the frustum of a cone with small apical angle. The chief improvement, however, is the addition of a hinged three-piece, soft-pedal bar, controlled by three levers. By means of this expression may be imparted manually to music which as controlled by the music sheet alone would be perfectly flat.

Most inventors, however, have preferred to follow in the line marked out by Hipp, and in it personally I am most interested. I have called attention to the fact that Hipp inserted resistance in the circuit with a view to varying the strength of the magnets and so the intensity of the blow of the hammers. Although du Moncel described Hipp as obtaining in this manner a satisfactory range from forte to piano, a little consideration will disclose an essential weakness in the scheme. For any given resistance introduced into the main circuit will have an effect the greater the more magnets in circuit, a very undesirable result. Yet it was not until some thirty years later that it was shown that the true method is to insert a separate resistance in each branch circuit. Before condemning too severely the electrical inventors occupied with piano players for their slowness in discovering this point, it might be well to take into consideration that an analogous fault still exists in some of the pneumatic players of to-day.

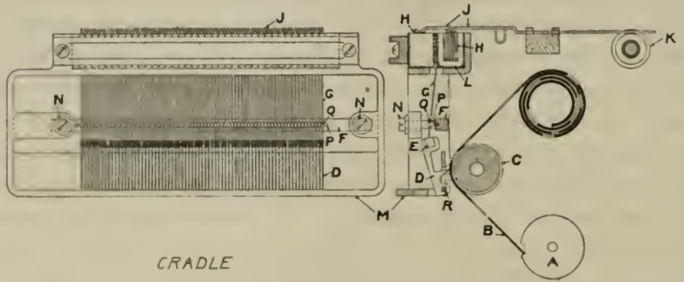
In order, however, that insertion of resistance may give effective control of the magnetic pull, and hence of the touch on the piano keys, it is necessary that the magnets should be peculiarly constructed. It is necessary that the attractive force should be near its maximum when the armature first begins to pull on the piano action. When a magnet is employed in which the attraction on the armature rapidly increases as the armature moves towards the poles, it is practically impossible to control the movement by the control of the current. In such a case the current that is required to start the armature from its initial position suffices for a violent blow at the end of the path. Hipp perceived this but it was overlooked by many of his successors.

Those who have had experience with pneumatic players know that one of the most serious difficulties with such instruments is the susceptibility of the paper music roll to atmospheric conditions. Naturally the same trouble is encountered when a paper roll is used in an electric player, and there are some new ones. The fact that the paper is pulled between a wire comb and a rotating cylinder instead of being drawn over a smooth tracker board does not make for better tracking. And again, if the electric pressure be high, there is a tendency to burn the paper where it acts as a circuit breaker; while if it be low there may easily be uncertainty as to contacts.

In a series of patents running from 1901 to 1904, T. B. Powers, partly in collaboration with M. R. Jewell, has shown a player combination designed to overcome these difficulties. Powers' direct contributions are more important than those of any of his American predecessors, and he has also shown great talent in his utilization of the elements he took over from the prior act. His most important improvements are the substitution of thin metal tape for paper in the music roll, and the introduction of individual resistance coils in the branch circuits.

In 1905 I acquired the Powers patents and organized the Telelectric Company to manufacture a player in accordance with them. Naturally in the course of manufacture a great many improvements in detail have been introduced and some of greater importance. It would be useless and wearisome to point all these out and I shall therefore content myself with describing the players now made, calling attention only to such changes as materially modify the musical results.

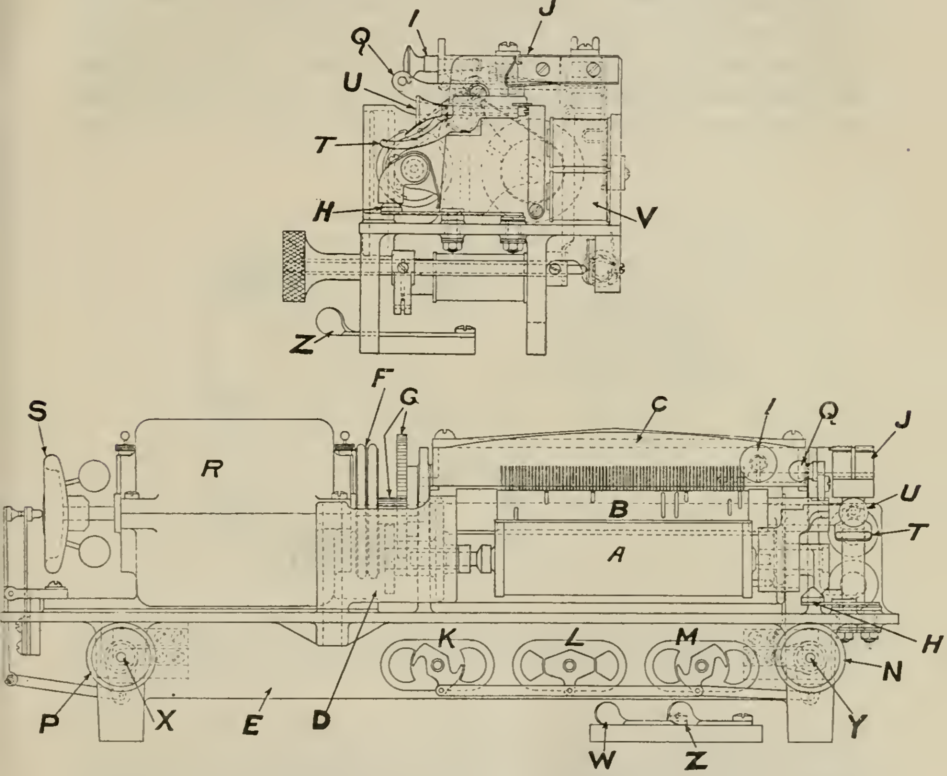
FIG. 1.



A, music-tape case; *B*, music tape; *C*, tracker roll; *D*, reading finger; *E*, ivory insulating block; *F*, contact bar; *G*, contact wire; *H*, resistance coil; *J*, comb wires; *K*, terminal; *L*, resistance coil frame; *M*, cradle casting; *N*, adjusting screws for contact bar; *P*, platinum strip and contact bar; *Q*, platinum bands on contact wires; *R*, swivel rod for reading fingers.

The apparatus in general plan recalls that of Hipp. The use of a metallic instead of a non-conducting roll has necessarily led, however, to a material change in the construction of the comb. In our apparatus each of the elements of the comb consists of two parts, a reading finger proper, and insulated from this a wire acting as a contact maker. The contact is made with a separate contact bar instead of with the tracker roll as in the Hipp apparatus. These elements, and a corresponding set of small resistance coils, are, in our standard sixty-five-note apparatus, set in a special frame, which, from its being pivoted in front to allow of a rocking motion, is usually called the cradle. The cradle is shown in Fig. 1, and its relation to the rest of the machine in the general view Fig. 2. In Fig. 3, the construction and relation of the reading finger *D* with its contact wire *G*, to the contact bar *F* and the resistance coil *H*, is clearly indicated. The ivory block *E* serves to insulate the reading finger from the wire. It will be also clear from this figure that the metal music tape *B* when unperforated will lift the reading finger *D*, and so break the connection between the contact wire and the bar *F*. The wire *J* is one of a set forming a second comb serving to maintain connection between the resistance coils and the cable terminal *K*. When the cradle is rocked upwards the resistance coil is raised and, as an inspection of the figure will show, resistance is intro-

FIG. 2.

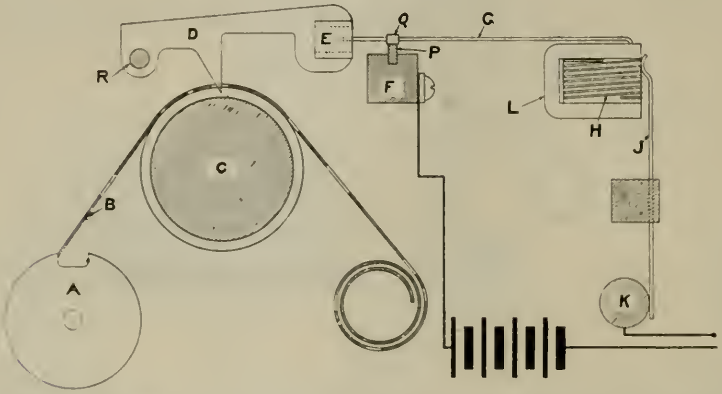


A, music-tape case; *B*, music tape; *C*, cradle; *D*, swinging carriage; *E*, base; *F*, rubber belt drive; *G*, gears; *H*, starting switch; *I*, expression cut-out knob; *J*, trip switch; *K*, forte expression magnet; *L*, medium forte expression magnet; *M*, piano expression magnet; *N*, expression handle; *P*, tempo handle; *Q*, carriage latch; *R*, motor; *S*, governor; *T*, lifting lever; *U*, trip button; *V*, trip magnet; *W*, base subduing switch; *X*, sustaining pedal button; *Y*, soft pedal button; *Z*, treble subduing switch.

duced into each circuit. This rocking of the cradle may be effected either automatically by means of the magnets shown at *K, L* and *M* in Fig. 2, or manually by means of the handle shown at *N* in the same figure.

The winding and unwinding of the tape constituting the music roll is accomplished by means of an electric motor *R* provided with a governor *S*, Fig. 2. The transmission from the motor to the winding and rewinding rolls is through a pair of rubber belts and a set of gear wheels. The lifting of the tracker roller into place by means of the lever *T*, Fig. 2, puts the winding gear in mesh, while the lowering of the same roller shifts to the rewinding gear. This shift may be effected by pressing the button *U*, but ordinarily it is effected automatically at the end of the selection by means of the trip magnet *V*, Fig. 2. At the end of the music tape an opening is cut which allows a special reading finger to close the circuit of this trip magnet, thus dropping the tracker roller and shifting the gear.

FIG. 3.

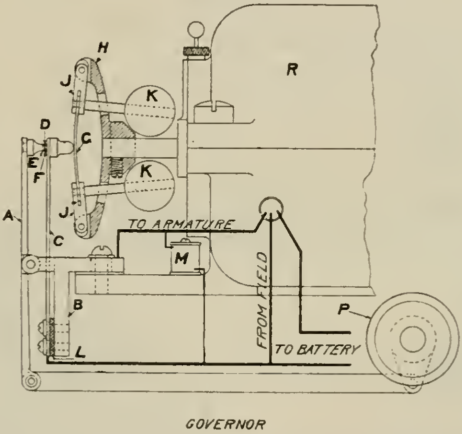


A, music-tape case; *B*, music tape; *C*, tracker roll; *D*, reading finger; *E*, ivory insulating block; *F*, contact bar; *G*, contact wire; *H*, resistance wire; *J*, comb wire; *K*, terminal; *L*, resistance coil frame; *P*, platinum strip in contact bar; *Q*, platinum band on contact wire; *R*, swivel rod for reading finger.

For our purpose a governor must not only maintain a steady speed, but it must maintain steady any speed the operator may choose. The simple make-and-break ball governor shown in Fig. 4 accomplishes this remarkably well. The speed is varied by shifting the position of the contact arm *A* by means of the handle *P,* Fig. 4. This simple and absolute control is of especial value in accompaniments. Because of it, it becomes easy for any singer to accompany himself.

Fig. 5 shows two views of one of the actuating magnets and the means of attaching the armature to the piano key. It will be observed that the rotary armature is so shaped and set with reference to the poles as to ensure a strong initial attraction which, as before pointed out, is necessary in order that the touch on the piano keys may be effectively controlled by varying the current in the magnet winding. A small screw eye is put into the key, the connection between this and the armature being made by means of a flexible steel wire. The eye of the screw carries a small rubber cushion to prevent any clicking from being developed by the wire striking against the screw. It will be observed that this method of connecting leaves the keys entirely free at all times, so that, for instance, one may play a duet with the electric apparatus as a partner.

FIG. 4.

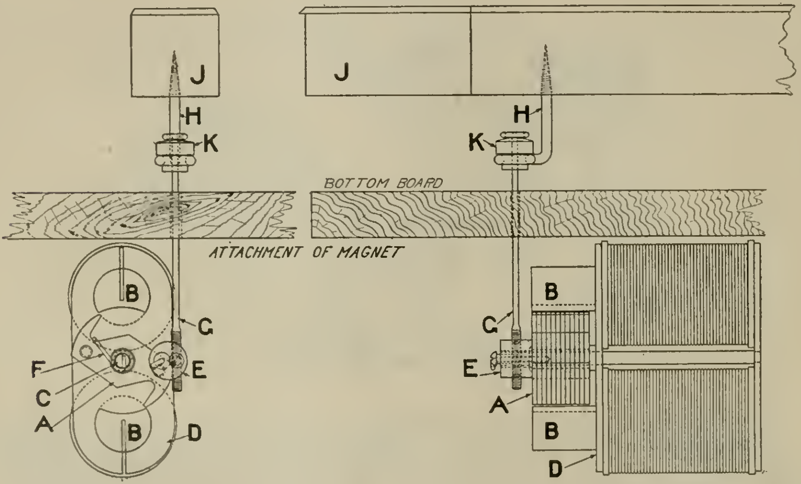


A, contact arm; *B*, governor bracket; *C*, follow spring; *D*, point of break; *E*, platinum point on contact arm; *F*, platinum point on follow spring; *G*, governor spring; *H*, governor disc; *J*, hinges for governor spring; *K*, governor balls; *L*, insulation block; *M*, shunt coil; *P*, tempo handle; *R*, motor.

Magnets similar to the key magnets but larger are used for operating the pedal bars. These magnets are controlled by perforations made at suitable points in the music tape, or they may be operated at will by the buttons *X* and *Y* shown at the centres of the handles *P* and *N* in Fig. 2.

The music tape is a brass ribbon five inches wide and three-thousandths of an inch thick. The perforations for the notes are arranged in a similar manner to those on the paper rolls, but on a much smaller scale. The brass is only one-third as long as the paper for the same music. That the same proportion is not exactly preserved in width is due to the fact that our brass tapes carry other perforations than those corresponding to the notes. Perforations, as stated already, are provided for controlling the action of the pedals, for varying the resistance in the circuit and for shifting to the rewinding gear at the end of the selection.

FIG. 5.

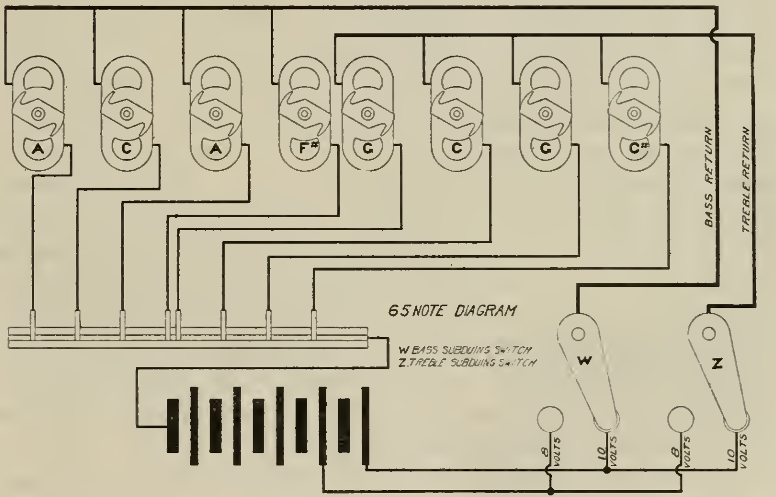


A, armature; *B*, poles; *C*, armature shaft; *D*, brass yoke; *E*, swivel; *F*, armature return spring; *G*, pull-down wire; *H*, screw eye; *J*, piano key; *K*, rubber buffer.

The cutting of each selection is so arranged that the tempo of any selection will be normal for a fixed motor speed. This applies even to what may be called the normal variations from the standard tempo of the selection. Such variations are incorporated in the cutting. Variations in tempo to suit special tastes may be readily introduced by turning the handle *P*, Fig. 2, right or left as may be required.

Apart from the variation in tempo, the means of obtaining expression so far described consist in the variable touch on the piano keys obtained by the use of variable resistance, and the use of the pedals. If I have succeeded in making my meaning clear, it will be evident that two distinct purposes have been kept in view in the building of the Telelectric player. On the one hand we have attempted to build a machine which, when left to itself, will reproduce with perfect accuracy the music as written by the composer and with the proper interpretation. From this standpoint we have cut the music rolls, carefully avoiding all "adaptations" to make it easier for the player, and all the whimsies of interpretation of this or that virtuoso. For steady use and to meet the general cultivated taste we believe standard normal music is best. And we are also of the opinion that music so cut forms the best basis for those who wish by manual control to obtain a personal interpretation. And on the other hand keeping in view this desire for a specialized or individualized interpretation, we have provided extremely simple means by which any one with special tastes may vary the expression to suit himself.

FIG. 6.



W, bass subduing switch; *Z*, treble subduing switch.

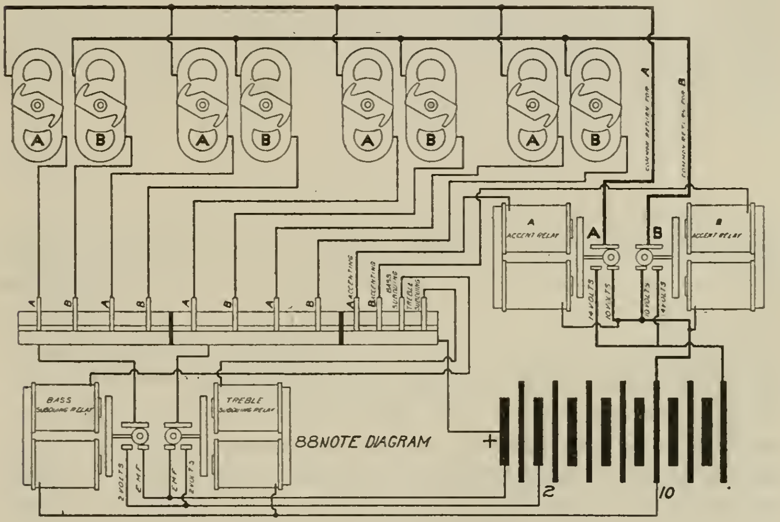
Still further control of expression is of course desirable. In many cases a much improved effect is produced by playing bass and treble with different force. I have accomplished this in a simple manner by dividing the magnets into two groups so that two different electromotive forces may be simultaneously used. The electromotive forces may be varied by means of the switches

W and *Z* in Figures 2 and 6. This improvement is incorporated in all our sixty-five-note standard players. If I were to use the language of the piano player advertising agent I should describe this change as causing the accenting of individual notes, and as bringing out the melody. This language is far too strong, and, like all exaggerated language, it is not only harmful in its direct untruth, but it leaves us without terms to describe further improvements when actually made. Of course when the notes are thus divided into two groups all notes occurring simultaneously in either group are struck with equal force.

The musical advantage of a distinct individual accent is so great, however, that for two years I have largely devoted my efforts to securing it, with the results that are shown in the eighty-eight-note player which I exhibit here to-night. The simplest way to get an individual accent would be to practically duplicate the tape using different electromotive forces on the parts. Imagine the music tape as made up of two parallel longitudinal bands, corresponding to a divided contact bar with a permanently maintained difference in potential. Imagine also the reading fingers, rheostats and other accessories duplicated in each section, *i.e.*, one wire from each section for each magnet and piano key. Then it will be clear that a note would be accented or not, according to which section carried the corresponding perforation. Unfortunately this system calls for music rolls nearly twice the width required for non-accenting rolls, greatly increases the cost of the rolls, and is otherwise clumsy.

To keep the roll within reasonable dimensions and at the same time obtain the requisite control over the force of the blow supplied to different keys was the subject of much thought. I became satisfied that some system of grouping the notes must be used, and I worked out several plans for the control of the groups. These plans with the exception of that now being introduced into practice it is unnecessary to describe. As to the grouping, the first idea that presented itself was, instead of simply dividing the scale into bass and treble, to cut it up into numerous sections. I should thus be able to confine the accent within a narrow section. Unfortunately, until the section is reduced to the compass of but a single note, it is always possible that it may contain a note which it would be undesirable to accent. Indeed the narrower the section the more important it is that it should not contain a second accented note. The next idea that presented itself was to include in each group only notes of the same name; C's in one group, C sharps in another, and so on to the end of the scale. This is very much more satisfactory. Even if two notes should happen to be sounded in one group, as would occur sometimes, so that both might catch the accent, as the two are consonant, the effect would be substantially that of accenting the single note. Indeed with the old-fashioned player the accenting of a note can often be simulated by cutting its octave to sound with it. I thought it desirable, however, to go further than this, and on this octave grouping I superimposed the division into bass and treble. In consequence of this double grouping it is possible to obtain four different strengths of blow on the piano keys simultaneously. This capability added to the power of control over expression already described ought to satisfy the most exacting requirements.

FIG. 7.



The arrangements for carrying out this method are clearly shown in the diagram Fig. 7. The key operating magnets are from one end of the circuit divided into two groups, and from the other end into twelve. The source of electromotive force has four terminals, ordinarily 0, 2, 10 and 14 volts. Switches are so arranged that the wires leading to the magnets on the one side may be connected either to 0 or the 2-volt terminal, and on the other to either the 10 or the 14. These changes are independent of each other. We, therefore, have the power to supply any magnet with 8, 10, 12 or 14 volts at will. The switches are operated by quick acting electro-magnets, and these, in turn, are controlled, either by special perforations in the music roll, or at will by the operator through specially provided buttons. At the will of the operator also any one or more of the means of expression may be left music roll controlled while he manually controls the rest. He may pick out that portion of the expression in which he feels he can best express his individuality, leaving the rest to the machine, or he may take into his hands the whole control, and make the expression entirely his own.

A WORD AS TO THE FUTURE.

I fear the idea is still prevalent that a piano player must be necessarily inartistic. Logically those who hold this idea should condemn the piano also, for piano playing is but mechanicalized harp playing. In all arts and crafts alike there is and always will be a place for hand work. Pioneer work falls to the hand, and in the arts especially there is a peculiar grace arising from the flexibility of the instrument. But power, accuracy and precision are the feature of the machine. The grace of the harp, the fact that it allows of a more highly individualized playing, has in nowise prevented the more mechanical piano from becoming a hundred times more common, and the favorite instrument of great artists. And while, as in passing from the harp to the piano so in passing from the simple piano to the piano and player, there may be in some respects a loss, I am fully satisfied that for this loss there is a more than equivalent compensation. And in speaking of compensation I have in mind not only that thousands are reached by the player who otherwise would be deprived of all good music, but I have also in view to some extent direct artistic compensation. While the piano mechanism restricted the performer in some directions as compared with that of the harp, in others it opened out to him a wider field. And the player in turn will again widen the field. The composer will no longer have to think of the limitations of ten fingers on two hands. Consider what this may mean in transcriptions of orchestral music, or, if we have the daring, let us even dream of what it may mean in original piano music.

There is another reason why our ultra-artistic piano lovers should take a more generous attitude towards the player. The growth of the piano trade, if it did not actually hinder the making of harps, at least did nothing to advance that art. The piano playing business on the other hand tends to enormously increase the number of pianos in use, and each of these pianos should be recognized as the possible means of development of a future artist. And surely the struggling musician will be none the less likely to develop into an artist because he has at his disposal a machine which will make it possible for him to hear the great music of the world. As well might we say that it would be harmful to a young painter to be placed in possession of a set of photographs of the world's masterpieces in painting.

As for myself I am simply glad that I have been in any way able to contribute towards placing culture and refinement within the reach of all.

WATER-RESOURCES INVESTIGATIONS BY THE GEOLOGICAL SURVEY.

WORK ADVOCATED BY PROMINENT ENGINEERS.

The necessity for determining the extent and character of the water resources of the country, if such resources are to be wisely utilized, is emphasized by the Director of the United States Geological Survey in his annual report, now in press. It is pointed out that prominent engineers have long advocated the extension of Government investigations of water resources, and that the work in the United States is not commensurate with that done in many European countries. If the United States were to provide for the prosecution of water-resources investigations on a scale of thoroughness equal to that of Switzerland, for example, it would appropriate $11,000,000 annually, a sum 110 times greater than the present annual appropriation for similar work in this country.

A brief statement of a few of the industrial and social problems of the present day in which the utilization of water is the controlling factor is made in the report, as follows:

FLOODS.

The average annual damage by floods in the United States has never been accurately determined, but such investigations as have been made indicate that the loss must be at least $100,000,000 annually. It appears that in many parts of the United States the proper expenditure of an amount equal to one year's flood loss would prevent future floods; in other parts of the country the cost would probably equal the losses of two or more years; but in every locality prevention could be accomplished by an expenditure equivalent to the losses from the floods of a few years.

In few flood regions, however, could this result be accomplished except under federal action. Most of the rivers are interstate. Their basins were defined many thousands of years before State boundaries were conceived. The proper treatment of the flood question must therefore follow the limits imposed by nature rather than the artificial lines defining the sovereignty of the various States. Prevention of floods is purely an engineering problem, and the engineers who have thoroughly investigated it realize fully the necessity for federal regulation.

On another feature of this subject the engineering profession is also agreed, namely, that whatever means may be finally adopted to prevent this great devastation the results of investigations of rivers must be available to show their habits, flows, seasonal changes, and eccentricities; and, moreover, such investigations must extend over a period of years and be practically completed before remedial measures can be applied.

INLAND NAVIGATION.

Several hundred million dollars have been expended by the Government for river improvement, and it is probable that as much, if not more, must be expended during the next decade. Whatever may be the system under which the United States shall make its improvements, all engineers agree that thorough investigation of rivers is absolutely necessary to the final solution of the problem.

IRRIGATION.

The United States is spending $40,000,000 in the construction of irrigation systems. The great factor that will determine the success or failure of this investment is the water supply. Whether or not there is water sufficient for any irrigation project can not be determined by mere inspection or by measurements made over a short period of years. When the reclamation act was passed, in 1902, it was possible for the Government to proceed at once with certain projects because the Geological Survey had on file the results of stream measurements showing that sufficient water was available for these projects. The Reclamation Service has no legal power to make general investigations of stream flow, and obviously it would be unjust to charge the cost of general investigations over all the arid West against specific projects. In other words, the continued investigation of the water resources of the country will safeguard $40,000,000 of government expenditure.

DRAINAGE OF WET LANDS.

More than 80,000,000 acres of the best agricultural lands in the United States are unproductive because they need drainage. The lands are so widespread that their drainage is being agitated as a national issue, for many believe that these wet lands should be reclaimed under federal authority, as are the arid lands of the West. To the success of this work the investigation of water resources, as well as accurate topographic mapping, is as necessary as it is to the success of irrigation enterprises.

WATER POWER.

The United States Government is at the present time a large owner of water-power privileges, and investigation of those privileges is a matter of public duty. In the absence of specific information concerning its value, a water power may be easily acquired, and water-power rights have thus gone from the control of the Government for a fraction of their real value, not for useful development, but for speculative holding, which involves keeping them for long periods in a non-productive state. Enormous water powers outside of the public domain are being procured at extremely low valuations, and although the development of these powers will undoubtedly be of ultimate value to the people at large, their extent and value should be matters of public record.

FRANKLIN INSTITUTE

(Stated Meeting held Wednesday, December 16, 1908.)

THE TELEGRAPHONE.

THE PRINCIPLES EMBODIED IN IT, ITS ACCOMPLISHMENTS IN ACTUAL EXPERIENCE, AND ITS INFLUENCE ON OUR COMMERCIAL AND SOCIAL LIFE.

BY
CHARLES K. FANKHAUSER.

Mr. President, Ladies and Gentlemen:

I deem myself most fortunate in having the honor to address you to-night on the subject of the telegraphone, to have an opportunity to expound here, in the home of Franklin, and in the presence of his disciples, the principles which underlie the most unique application of the great force which Franklin was the first to bring within the familiar control of science. For I deem the telegraphone to embody nothing less.

In all its branches, the electrical force is of most absorbing interest. From the delicate mechanism of the telephone to the giant organism of the huge dynamo which drives the power of ten thousand horses over the copper wire, the art is full of wonders. But of them all, I believe, from an intimate study of the subject, that the telegraphone involves at once the most amazing and the most profound phenomena in the realm of the science. I may be mistaken in this. My enthusiasm for this instrument, with which I have dwelt in intimate relation for more than three years, may have warped my judgment; but I do believe that an investigation on your part will confirm me in my conviction that we have here an invention or discovery, which, in many respects, is the most remarkable and unique ever made.

To transport human speech over a distance of one thousand miles is a wonderful achievement. How much more wonderful, then, is the achievement that makes possible not alone the transmission of speech over three times one thousand miles or ten times one thousand miles, but its storage at the receiving end, so that the exact sentence, the exact intonation of the voice, the exact timbre, may be reproduced over and over again, an endless number of times. This feat the telegraphone makes possible. It not only records human speech electrically, but, by its application to the telephone, it makes possible long distance transmission to a point undreamed of heretofore. I believe in fact that this machine solves the problem, which has halted long distance telephony this side of the Rocky Mountains, and that the principles which it embraces may eventually give us what up to this time has been a mere dream, a commercial telephone service to Europe. In this belief I am reinforced by the opinion of some of our greatest experts in the telephone art.

But for the purpose of my address this evening, I will not go further into the subject of long distance telephony than to state the fact, but will confine myself rather to an exposition of the principle embodied in the telegraphone, its accomplishments in actual experience, and its influence on our commercial and social life.

The principle upon which the telegraphone is based is that a mass of tempered steel may be impressed with, and will retain magnetic fluxes varying in density and in sign in adjacent portions of its mass.

The action of the wire telegraphone in "recording" is as follows:

A tempered steel wire is caused to pass at a uniform rate of speed successively before and in contact with the pole of a soft iron electro-magnet designated as the "erasing" magnet, and before and in contact with the pole of another similar electro-magnet designated the "recording" magnet.

Through the winding of the "erasing" magnet is passed an electric current of sufficient strength practically to saturate the steel wire magnetically and a portion of this current is caused to pass through the winding of the "recording" magnet in a direction to give the magnet a tendency to reverse the direction of the magnetic flux in the steel wire in order to bring the wire into a magnetically neutral condition.

The winding of the "recording" magnet is also included in the circuit of the secondary winding of an induction coil, the primary winding of which is in circuit with a battery and telephone transmitter.

Sound waves as from spoken words, etc., impinging upon the transmitter diaphragm and through its vibration setting up correspondent current waves in the circuit of the secondary winding of the induction coil and " recording " magnet will cause varying fluxes to traverse the magnetic circuit of the recording magnet, which will cause similar fluxes to be impressed upon successive portions of the steel wire as it passes before the pole of the " recording " magnet.

In "reproducing" the record, the "erasing" current is discontinued and a telephone receiver is introduced into the circuit of the " recording " magnet winding.

Upon causing the steel wire carrying the magnetic " record " to again pass before the pole of the " recording " magnet at the same speed and in the same direction as when making the record, the varying fluxes in the wire will set up corresponding fluxes in the magnetic circuit of the recording magnet, thus inducing current waves of similar value in the winding and circuit of the recording magnet and telephone receiver.

The receiver diaphragm vibrating in unison with these currents will set up sound waves similar to those acting upon the telephone transmitter in making the record.

Altogether there have been few inventions or discoveries involving more beautiful principles of science. At almost every step, in tracing the development of Mr. Poulsen's work, the scientific mind is fascinated and carried away with enthusiasm. And had Mr. Poulsen accomplished nothing else except the contribution that he has made here to science, his work would have been sufficiently great to entitle him to world-wide and lasting distinction. It happens, however, that we have, in the principles that govern the telegraphone, not only a great scientific discovery, but one that in its practical application means much to the world. And it is this phase of Mr. Poulsen's work that appeals to me most strongly.

Nor is this unnatural in view of the fact that I am not a scientist but a man of practical affairs. Science, I believe, is mainly important in this world in so far as it affects the well-being and progress of the world. The snow flake and the ice crystal that forms on the window pane on a frosty night, are both beautiful works of nature, and their formation and construction truly and properly appeal to the scientist and the student. But they are evanescent and have no practical value to the world.

And so, too, many other great and beautiful manifestations of nature involve deeply interesting phenomena of science, but if they mean nothing to the comfort, or well-being, or progress, or development of man, they are entitled to little consideration at his hands. The true measure of the value of scientific discovery must always rest on the service rendered to the world.

I deem it fortunate, therefore, that Mr. Poulsen's invention ranks very high measured by this standard, as well as by the standard of pure science. For it is my profound conviction that the telegraphone is destined to exercise a great influence on industry and commerce, and on social life and development. It has been stated, and to my mind correctly, that the telephone has done more to enhance the wealth of the world than almost any other invention. It has added vastly to the producing power of the community, it has added vastly to the comfort of the community, it has added vastly to the social life of the community. It has taken the farmer out of the terrible isolation, which, from the beginning of civilization, has blighted his life, and has put him in touch with his fellows. It has made the urban dweller a unit in the closest brotherhood of man the world has ever known. It has accomplished more in the economic life of the world than any of us, even the most optimistic, realizes.

But there has always been a gap in the perfected work of the telephone. This imperfection is similar to the gap that existed in the usefulness and utility of the spoken word, until Gutenberg gave us the art of printing. It is my belief that what type has been to the spoken word, the telegraphone will be to the electrically transmitted word, to the system of communication which is now of such universal application in the world. As printing spread learning and civilization among the peoples of the earth, and influenced knowledge and intercourse among men, so I believe the telegraphone will influence and spread electrical communication among men.

It has always been a drawback to the general use of the telephone, that the messages transmitted have been wholly evanescent, that it has been impossible to preserve or present an authentic record of conversation over the wire. Few of us realize how this has restricted the use of this all-important device. With the telegraphone in use we may now deal as freely in important affairs by means of the telephone, as we have dealt heretofore face to face, or through instruments of writing. We have, in fact, in Poulsen's invention an electric writing as clear and distinct as the writing by hand, and an absolutely legal and conclusive record. We may with the telegraphone make contracts and agreements, though we are a thousand miles apart, that are as binding as any instrument executed in ink; we may deal instantaneously, no matter how great the distance that separates us, or how important the occasion or the questions involved, in the full knowledge that nothing is left to chance or misconstruction, wilful or accidental. This alone means a great acceleration of affairs, and a consequent progress of the world.

Based on my experience in the field, I believe that the next few years will see a telegraphone installed in the office of every doctor, every lawyer, every banker, in the counting room of every trust company, and of every industrial or commercial establishment, large or small. I sincerely believe that there will be few residences of the middle class or the well-to-do, that will be without an instrument.

A doctor may leave his office in the assurance that any patient who calls, either in person or by telephone, may leave a complete record of his case. A lawyer discussing with his client, or with the opposition, the details of the settlement of a case, will find nothing left to chance with the telegraphone as a witness. The broker taking orders over the telephone to buy or sell stock, or execute any other form of commission, will have unimpeachable evidence as to the matters involved. The banker, the trust company and the industrial establishment will feel at liberty to transmit and receive orders of the most important character over the wire where now they must take the chance of a dispute or even a lawsuit in every instance where instructions are received or sent by telephone.

The great manufacturing and commercial establishments will be in direct communication with their departments in the true sense, and every order will be set down in exact terms for future reference.

In railroading, the telegraph, as an instrument for dispatching trains, will entirely disappear. Already the telegraph for this purpose is on the wane; but its complete substitution has heretofore been impossible because of the fact that it is absolutely necessary on important divisions that there should be evidence, that there should be a record of train movement orders. A figure misplaced in transmission, often a comma misplaced, has precipitated some of the most frightful accidents in the history of travel. With the telegraphone as a recording device at the transmitting and receiving ends, there can be no possible chance of such an error in transmission. The message as it is delivered is recorded exactly, automatically, at the other end, and may be repeated and definitely checked up.

In the transmission of news or stock quotations, and other events that are dependent upon instantaneous communication, the telegraphone will work changes equally important. Recent years have seen a great revolution in the methods of reporting. The telephone has come strongly into the field, so that newspaper offices, stock and mercantile exchanges, are almost entirely dependent upon their telephone service for quick and accurate information. Yet, as matters now lie, this telephone service, though accelerating news transmission to an extraordinary degree, is still far away from the point that may be reached with the addition of the telegraphone. Thus, while at the present day reporters telephone their news story to their offices, they must still be rewritten at the receiving end. They may be taken by short-hand, or they may be, as is the general usage, written out in long-hand by the persons who receive the communication at the newspaper offices. With the telegraphone the matter may be dictated at the transmitting end in such a manner as to be immediately available. The only thing necessary is to equip the compositor at the typesetting machine, with a headpiece so that he may set the story as fast as his fingers will work.

Altogether, the possible applications here are so manifold that I deem it needless to pursue them further. It requires no particular powers of imagination to see that the whole system of news transmission of whatsoever nature, or character, is certain to be affected to an extraordinary extent, if not entirely revolutionized through this device.

Leaving the field of telephone recording we naturally follow the machine into the field where it has its next greatest usefulness, that is, commercial dictation. I doubt that many of my hearers have any idea of the enormous extent to which mechanical dictating machines are now employed. I refer to what is technically known as the commercial dictation; that is, to the field in which stenographers were formerly the only available medium for the business men who had any number of letters to write. From the great mail order houses, where from two to three hundred correspondence clerks are constantly at work, to the minor establishment where the entire correspondence is looked after by one man, there are thousands upon thousands which employ the ordinary talking machine of to-day for the purpose of letter dictation. The field here is growing constantly, as it has been demonstrated that there may be effected not alone an enormous saving in actual money, but in time, and accuracy, that is, with the aid of the talk-machine, the correspondent can dictate from two to three times as many letters as he can through the medium of the stenographer.

In this field the telegraphone has advantages over the ordinary mechanical talking machine, that must appeal to everyone upon the slightest investigation. Telegraphone records are indestructible. The medium employed may be used over and over a thousand to ten thousand times. There is no breakage of wax cylinders, no necessity for shaving cylinders until they are worn out, no cost for replacement and no interruption to replace cylinders when one is filled. Instead of cumbering the desk with a dictating machine, the telegraphone may be kept in any part of the building, the only apparatus necessary at the desk being the ordinary transmitter and receiver and an electric indicator to show the position of the wire on the spools. The operator has perfect control of his record, may erase or retrace any part of it at any time by simply pressing the button.

In the larger establishments where hundreds of mechanical dictating machines are now in use, by assembling the machines and transcribers in one room, one half as many telegraphones will suffice, for the reason that at no time are all the machines in use, and the operator, sitting at his desk, may be switched on to any machine that happens to be idle at the moment.

In every large office building or hotel, dictation may be given to the public stenographer without leaving the office or room. It is only necessary to pick up the telephone receiver, ask for the public stenographer, have her connect your phone with the telegraphone and then sit down and dictate into the receiver.

These are not mere fanciful imaginings, but practical conditions based on experience. The court reporter, without leaving the court room, may dictate his minutes to a machine that may be a hundred paces or a hundred miles away, and the entire record may be accurately transcribed by a typewriter whom he may never see.

While the human stenographer may never be eliminated in important legal proceedings, it is highly probable that an additional check will be kept in every court room by the installation of a telegraphone which will eliminate all chances of human mistakes.

Everywhere in the field of human endeavor, where an accurate record of the spoken word is required or desired, the machine will be found silently, but accurately doing its work, leaving nothing to imagination, nothing to chance. This will mean much in human affairs.

I have purposely left to the last the part the telegraphone is destined undoubtedly to play in our social and scientific life.

Dr. George M. Gould, one of your most distinguished citizens, has painted for us most graphically the influence that the telegraphone promises to have on the advancement and welfare of the blind. In an article communicated to *Science* a few years ago, Dr. Gould, after setting forth the complete process of his experiments with the telegraphone, suggested an application of the invention, which he very properly said was " probably never dreamed of by Poulsen."

" Of what use," said Dr. Gould, " the now ludicrously cumbrous. expensive, slow and wearying embossed letters and libraries for the blind—the Braille, New York Point, Line Letter, Moon type, etc.? How vastly may be increased the ease of methods of reading to the sick, the infirm, the aged, of instruction to teachers, of the young, and others. A book can be read to the sightless or the invalid by the machine, while the patient lies in bed. Lectures, concerts, recitations—what one wishes, may be had at will. Skilled readers or expert elocution teachers could be employed to read into the wires entire libraries, and every taste would thus be easily supplied.

" There are several hundred thousand blind persons in the civilized world, and benevolence has long vied with charity in lightening the burden of their afflictions and mitigating the tragedy of their lives. One cannot imagine a more speedy and effective means than this of stimulating their '*esprit de corps,*' arousing mental, educational, and social progress, and of placing at their command the learning and science of the world. We are too slowly learning that there is no occupation, whether farming, mechanics, manufacturing, merchandising, or professional life, that may not be worthily, and that has not been successfully carried on by those without sight. To place within the reach of these this most helpful and noble device would put them at a bound so in touch with one another, and with profitable employment, that other charities in their behalf would lessen in demand and significance."

This picture of the great things that lie in the telegraphone for those afflicted with blindness, is, I believe, in no way overdrawn. Certainly no one is better qualified than Dr. Gould to speak of the possibilities that lie there.

Dr. Harris, United States Commissioner of Education, has drawn for us another picture of the possible use of the telegraphone,—how it may serve the interest of those who are tired and jaded. With the lights out, and lying comfortably in bed, too tired and restless to sleep, Dr. Harris points out, how the busy and over-worked man may listen to his favorite author, and soothe himself into a state of restfulness, avoiding entirely the strain and fatigue incidental to reading from a book.

Numerous distinguished alienists have gone at length into the possibilities of the application of the telegraphone in mental investigations. With the aid of a sensitive transmitter concealed in an innocent looking ornament and connected with a machine in another room, the patient may be examined at length, and a full record of the conversation made without arousing suspicion. It frequently happens that examinations made by alienists extend over a period of four or five hours, as the shadings of mental derangement are so fine that only the most minute and careful questions will bring them to the surface. Afterward, the examiner must depend entirely upon his memory for the record, and in case of court proceedings he is entirely at the mercy of the attitude assumed by the patient on the witness stand. In examination in open court, persons mentally deranged manage often to conduct themselves in such a way as to deceive the most expert. It is only in private conversation that they allow their hallucinations to come to the surface.

In other branches of medical science, also, the telegraphone has demonstrated itself of exceptional importance. With its aid we may have a complete record of the heartbeat, or respiration, and of other physical phenomena, essential to correct diagnosis.

In the arts, the telegraphone is certain to play as important a part as in science and industry. It reproduces perfectly all musical tones. It will, therefore, occupy a strong position in the amusement field. It takes all the fine shadings of the human voice, and becomes, therefore, invaluable in language instruction. There are to-day thousands of talking machines in use for this purpose. But none reproduce the aspirates or the fine soft tones of the Italian and Spanish. The telegraphone, on the contrary, catches and carries them all. Not a sound is lost, not an inflection, not a whisper.

What other applications may come of the machine in this and other fields, I am not prepared to say. But past experience shows that there will undoubtedly be many, of which, like Poulsen, we have " never dreamed."

THE DEVELOPMENT OF VARIABLE SPEED MOTORS.

[Report of the Franklin Institute, through its Committee on Science and the Arts, on the Variable Speed Motors made by the Electro-Dynamic Company, of Bayonne, N. J., under the patent issued to Mathias Pfatischer. Sub-Committee: Richard Gilpin, Chairman; Richard Binder, Carl Hering. No. 2395.]

These variable speed motors are built under the patent issued to Mathias Pfatischer No. 775310, dated November 22, 1904, the subject of the patent being the design of shunt wound electromotors capable of application to the individual driving of machine tools and other apparatus at any desirable speed and duty which may be required of them, at the same time being under perfect control and operating at the highest efficiency and with the minimum amount of volume and weight for a given duty.

The chief characteristics of the inter-pole motor as made by the Electro-Dynamic Company comprise the provision of auxiliary field pole-pieces which are very small as compared with the main field pole-pieces and which are located between the latter and provided with magnet coils connected in series with the armature, so that all of the current taken by the latter flows through the coils of this auxiliary field which are so proportioned and arranged as to give the proper magnetic field for commutation.

All the coils of this auxiliary field being connected in series with the armature, the weakening of the field of commutation by an increased load is prevented and the auxiliary poles produce the compensatory field of commutation independently of the main field which, with an increased number of revolutions of the armature, must be correspondingly weakened; moreover, the function of the auxiliary poles is independent of the direction of rotation of the armature, because if the latter is reversed the current in the auxiliary field is also reversed.

The above construction and arrangement provides a motor, which, with the brushes equal distance between the poles, is capable of reversing its direction of rotation without detriment and effects commutation in either direction of rotation without sparking, not only with the variable load but also at variable speeds.

The control of electro-motors by varying the field magnetism is well understood to be the most satisfactory, efficient and economical method, but with standard designs of motors is limited and necessitates constant adjustment of the point of commutation, whilst the method as described above overcomes entirely all the weaknesses in this method of control and allows of a very considerable reduction in the weight and volume of the motor and increase in efficiency, as stated previously.

The application of the inter-pole to shunt wound motors gives the following advantages:

First.—Constant speed for all speeds at any controller position.

Second.—The desired speed can be obtained by the movement of a small rheostat handle, the motor responding instantly.

Third.—Such a motor will run full load equally well in either direction.

Fourth.—Under any variation of speed or load, perfect commutation takes place; in other words, there is no sparking at the brushes, this being true even with heavy overload conditions.

Fifth.—Such a motor has great compactness of design, its weight being very much less than standard motors capable of the same horse-power output at any given number of revolutions, the space occupied being also very much less.

Sixth.—Such a motor has the highest possible efficiency at all speeds, and from its novel method of design, using ball-bearings, and compact field frame, it can be placed in any position desirable for operation.

Seventh.—Such a motor installed in mills and factories requires a very much more simple system of wiring, inasmuch as a single voltage system can be used, in place of the three and four voltage wiring systems usually installed.

While the idea of the inter-pole is not new with the Electro-Dynamic Company, yet the development by the Electro-Dynamic Company of a practical variable speed motor having this characteristic method of control, has reached a high rate of perfection and made the application of motors to the individual driving of lathes, planers, pumps, fans, refrigerating compressors and other applications highly successful. The Institute, therefore, recommends the award of the JOHN SCOTT LEGACY PREMIUM and MEDAL to Mathias Pfatischer, the inventor, for his development on the above lines.

Attest: ALFRED RIGLING,
Acting Secretary.

Philadelphia, May 6, 1908.

GOLD AND SILVER IN THE PHILIPPINE ISLANDS.

FIRST RESULTS OF AMERICAN MINING.

Although gold mining has been carried on in the Philippine Islands for several hundred years and the aggregate value of the product has been great, exact records of production have not been kept. Since the American occupation of the islands, however, there have been much prospecting and considerable development of gold and copper deposits, principally of the former; but until 1907 the production was confined chiefly to placer washing and gopher mining for gold by the non-Christian tribes of the hills. During the nine years ending with 1907 the annual production by the natives of the islands probably averaged about 1,500 fine ounces of gold, valued at about $31,000. The total production by Americans and Europeans from 1898 to 1906, inclusive, probably did not exceed 600 fine ounces, valued at $12,400. The preparatory work which had been carried on by the American miners for several years began to bear its first real fruit in 1907, and statistics for that year, collected by the division of mines of the Bureau of Science at Manila, are now available.

The total production of gold in the Philippine Islands in 1907 is given by the division of mines as 4,540 crude ounces. At the average fineness of 0.850, this would represent 3,859 fine ounces, valued at $79,773. The production of silver is given as 83 fine ounces, valued at $55.

Although gold occurs in many islands of the group, the production of 1907 is credited to but two—Luzon and Masbate. In Luzon there are two producing provinces—Benguet in the northern part and Ambos Camarines in the southeastern part, on the Pacific coast. Masbate Island, southwest of Luzon, is part of the province of Sorsogon.

REPORT BY GEOLOGICAL SURVEY.

From a report on the production of gold and silver in 1907, published by the United States Geological Survey as an advance chapter from "Mineral Resources of the United States, Calendar Year 1907," by Waldemar Lindgren and H. D. McCaskey, the following extracts are made:

"For centuries the Igorots of Lepanto and Benguet have been mining gold, washing it from the streams or recovering it by impounding water in the hills and releasing it in floods over decomposed surface material, in this way procuring additional auriferous gravel and at the same time exposing the rich and narrow veins, which they worked to slight depths underground. The rich vein material thus procured contained free gold, which was recovered after the ore was crushed in crude stone mortars and washed by hand. The Igorots and later the Spaniards worked extensively the copper ores at Mancayan, in southern Lepanto, near the northern boundary of Benguet. For a number of years considerable quantities of copper were recovered, which did not, however, add to the output of precious metals, although the ores, which are mixed sulphides, arsenides, and antimonides, sometimes carry as much as $5 to the ton in gold, particularly in the pyrite. Since the American occupation production of gold by the Igorots has continued.

"In the Camarines, particularly at Paracale and Mambulao, European capitalists at one time did extensive underground work and erected modern mills. Their work was interrupted by the native insurrection of 1896 and has been resumed only in a small way by American miners in the last few years. There has been no production from the mines during the last twelve years. Before the Spanish conquest of the islands the natives of the Camarines worked the placers of these districts and have ever since made an annual production, which in the early years was of considerable importance. During the last year a dredge installed by American and New Zealand capital has made an output of gold most encouraging to the operators, and additional dredges are contemplated for this district.

"In the northern part of Masbate, at Aroroy, many old, abandoned gold mines of the Spanish régime, or of earlier times, have been actively prospected and partly worked by the American miners. The total production to date from Masbate has been small.

"Considerable gold is mined by natives in Mindanao in placer workings each year, but reliable estimates of the output are not available.

"Silver ores occur rarely in the Philippines, the one notable deposit having been found in northern Benguet, near the Lepanto line. This is in part native silver, but the deposit has not been developed. Lead ores carrying silver occur in the islands of Cebu and Marinduque, but they have not yet been developed."

SECTION OF PHYSICS AND CHEMISTRY

(*Stated meeting, held Thursday, December 17, 1908.*)

RECENT PROGRESS IN THE CHEMICAL PROCESSES OF THE TEXTILE INDUSTRY.

BY

FREDERIC DANNERTH, Ph.D.

WHILE it is quite true that the twentieth century has brought with it a host of inventions as well as actual improvements in the way of chemical preparations, unique processes, and labor-saving machinery, we must agree that by far the most important part of the program has been the amplification and development of ideas which were conceived in the latter part of the nineteenth century. This is, however, nothing unusual, for it has been observed that valuable inventions frequently lie unnoticed for a long time, awaiting, as it were, the magic touch of a keen-witted investor.

The subject which forms the title of the lecture for this evening may be conveniently divided in four parts, viz.: (1) newer preparations; (2) modern processes; (3) improved machinery; (4) the application of chemical engineering to textile problems.

NEWER PREPARATIONS

The preparations of known composition which have been placed at the disposal of our industry during the last ten years include fifteen materials, some of which were known in the laboratory many years previous but were inaccessible for technical processes because of their high price. The following groups may be distinguished:

Turkey-red Oil Group.—This includes the preparations known in trade as Monopol soap (original)—a highly sulphonated castor oil; Monopol brilliant oil—prepared from Monopol soap with addition of certain fats; Monopol oil (Schmitz), prepared from castor oil by sulphonation. The first-named material is not a true soap and was only so designated because of its resemblance to ordinary soap. These oils have been introduced as substitutes for the older turkey-red oil as levelling, softening and brightening agents. Added to the wetting-out bath they facilitate the penetration of cotton yarn. The foaming of dyebaths can also be avoided by the addition of small quantities of the oil. Tetrapol represents a solution of Monopol soap in carbon tetrachloride which has been recommended for scouring, fulling and degreasing.

Finishing Group. — Under this head may be mentioned diastafor, a specially prepared infusion of malt put on the market as a thick syrup. It may be used for removing the starch from calico prints, removing sizing from warps and preparing thickenings for printing or finishing. Gum tragasol is prepared from the fruit of the Carob tree and is used for preparing sizings and thickenings. It occurs in commerce as a jelly having a slight buff tint. A small quantity of phenol is added in order to prevent fermentation.

Hydrosulphite Group.—This includes a series of preparations related on the one hand to hydrosulphuric acid and on the other to formaldehyde. They are used for "discharge printing" and for stripping. In some cases zinc oxide has been added to the preparation in order to produce clearer effects on the discharged places. The commercial brands include: hydrosulphite NF (Hoechst), hyraldite C (Cassella), rongalite C (Badische), blankit (Badische). Rongalite, for example, is the sodium salt of formaldehyde sulphoxylic acid. This salt is quite stable, whereas the free acid is readily decomposed by air or water.

Degreasing Agents.—Carbon tetrachloride is the only member of this group which has attained to importance. Its present price is approximately ten cents per pound. There appears to be a large field for this substance as a degreasing agent for wool and in the cleaning of garments, as it is not inflammable.

Bleaching Agents.—Since the introduction of sodium peroxide by Castner more than ten years ago this substance has received increasing attention from textile bleachers, but the price at which it is offered makes it impossible to use it in the bleaching of cheaper cotton goods. One large field of usefulness is in the bleaching of tussah silk.

Mordanting and Dyeing Agents.—Formic acid and lactic acid have been on the market for several years, but have not yet succeeded in displacing acetic acid and the older assistants. Formic acid is sold as a 75 per cent. and 85 per cent. solution, and is particularly valuable because of its very strong reducing power. Lactic acid is sold in concentrations of 22 per cent., 50 per cent. and 80 per cent. It is also sold in the form of the ammonium compound (Lactamine) and as the sodium or potassium salt (Lactolin). Formic acid is prepared by the action of glycerin on oxalic acid while lactic acid is prepared by the fermentation of glucose.

Dyestuff Group.—The most important change in the manufacture of artificial coloring matters has unquestionably been the introduction of the sulphine or sulphur colors. Vidal black which was introduced in 1893 was followed in 1896 by the first katigen brown which in turn was the forerunner of the present important group. The sulphur dyestuffs are also known in trade as thiogene-, katigen- and kryogen-colors. Another sulphur compound which proved to be a dyestuff is the thio derivative of indigo which appeared in 1907 as thio indigo red and its more recent relative thio indigo scarlet R paste (Kalle). These two last mentioned sulphur dyes are applied to the cotton or wool fibre in a manner similar to vat indigo. In the group of important modern dyes belongs one which appeared as early as 1881, but which did not attain commercial success until 1897. I refer to the synthetic indigo discovered by Adolph von Bayer and technically prepared by Heumann in the year mentioned. From 1897 up to the present time the Badische Anilin and Soda Fabrik have been working diligently in perfecting the manufacturing process for this invaluable dyestuff. About the year 1900 the Hoechst Color Works succeeded in producing artificial indigo according to Pfluger's modification of Heumann's " Benzene Method."

Having thus briefly reviewed the newer preparations we will turn our attention to the

MODERN PROCESSES.

A process distinctly an American achievement is *the degreasing of wool* by means of volatile solvents first proposed by Mrs. Ellen Richards in 1879 and later developed on a technical scale at the Arlington Mills by Emile Maertens (1895). The petroleum naphtha at present used for this process is an undesirable necessity because of the fire hazard with which its use is accompanied. It may therefore be replaced before very long by the non-combustible carbon tetrachloride. The subject of cross-dyeing has been investigated very thoroughly during the last two years with reference to the production of "*resists on worsted yarns.*" In this process the yarn is dyed and then treated in a bath of tannic acid followed by a bath of tin crystals. The yarn so prepared may be interwoven with normal woolen yarn and then "dyed in the piece." The treated yarn has little or no affinity for acid and mordant dyes.

A German chemist named Kann has taken out a patent for a process of rendering *wool resistant to the action of alkalies.* The agent used for this purpose is formaldehyde. The idea is important as well as interesting, for by this means it may be possible to apply the sulphur colors to cotton-wool fabrics in the presence of such alkaline substances as sodium sulphide without any danger of rotting the wool.

The processes used in the preparation of *non-shrinkable wool* have up to the present time not been made public. Wool acquires this property to a small extent by treatment with a solution of chloride of lime. The fact that woollen yarn so treated acquires a silk scroop, a higher lustre and an increased affinity for dyes has been known for some time. Becke and Beil have taken out a German patent for the treatment of wool with concentrated sulphuric acid whereby its physical and chemical properties are altered. Fothergill has patented in England a process for rendering *cotton resistant to the "direct" cotton colors.* For this purpose the yarn is worked in a bath of tannic acid followed by a bath of tin crystals.

During the last decade a large number of processes have been suggested for the lustring of cotton fabrics with the object of *producing silk-like effects.* The methods of mercerizing warps and woven fabrics have been greatly improved, and, what is more important to the textile industry at large, the American patents were declared null and void by Judge Lowell of Boston in 1906. Another process of lustring and one which incidentally waterproofs the fabric is that in which a dilute solution of viscose is applied to the surface of the goods. In place of viscose another patentee has suggested a solution of cellulose in ammoniacal copper oxide. If the fabric be treated with this and subsequently passed over hot calenders and finally treated with an acid in order to remove the excess of copper, a lustrous finish is obtained. Still more recently Dr. Schreiner of the Bemberg Factory in Barmen, Germany, has introduced a purely mechanical process for lustring cotton fabrics. The goods are passed under an engraved calender to which a pressure of 35 or 40 tons is applied. The calender is engraved with fine lines (from 5 to 20 lines per millimetre). Although the German patent was taken out in 1894 it was fully ten years before the process was taken up in foreign countries.

The manufacture of fabrics with a "*fur finish*" is distinctly a modern process, having been brought to the United States from Russia but a few years ago. The raw goods for this process may be either a pile fabric (for Persian lamb effect) or it may be a fabric containing a loose spun, long, hair fibre filling (for broadtail effect). In the first instance the fabric is embossed, and in the second instance the effect is produced by napping and brushing. The production of *color effects on tapestry carpets* by printing has been developed considerably by the introduction of modern cylinder machines, which have taken the place of the older block printing. The *paper yarns* first exhibited at the Philadelphia Centennial in 1876 were produced on a technical scale at Richmond, Virginia, about the year 1890, but the successful production of high grade *paper carpets* was begun about the year 1900 by William Scholes at Germantown, Pennsylvania. The warp is in all cases made of hard spun cotton yarn, and the filling may be totally of paper or paper yarn and woollen carpet yarn. The designs are produced either on a Jacquard machine or by means of printing. Since 1904 Schuckert & Co. of Nuernberg (Germany) have perfected *an "Electrolyseur"* by means of which a solution of sodium chloride is electrolyzed, and the resulting chlorine liquor containing about 20 grams of chlorine per litre is used directly for bleaching purposes. As this corresponds to a lime liquor of about 5 degrees Baumé it will, as a rule, be necessary to dilute the bath. In the year 1898 J. Cadgene of Lyons (France) introduced a method of *applying dyes to silk fabrics* by means of a spray (Zerstaeubung). The effects produced depend on the number of spray nozzles, the pressure applied to the dye solution, and the motion given the nozzle. An ombre effect can be readily produced. The production of *artificial horsehair* by coating fine cotton yarns with solutions of viscose or pyroxilin forms the subject of a patent by C. N. Waite (U. S. P. 791,385). The product is, of course, much stronger than the varieties of artificial horsehair made wholly of viscose or pyroxilin. Fabrics made of this material have appeared on the market during 1908. Turning to the "*quick-retting*" *processes* for vegetable fibres we find that many inventors have made attempts to displace the painstaking Courtrai method of river retting by a chemical treatment. The process used up to the present in the United States is the cheap and wasteful "dew retting." Retting in one form or another is absolutely essential in the case of the bast fibres,—flax, hemp and jute, so that it is not astounding to find a long list of inventions along this line. One of the most promising systems is what is known as the Loppens-Deswarte retting tank. Although these inventors make no use of chemicals there are some others who have suggested various additions to the bath in order to hasten the fermentation and solution of the pectic matter of the stalks. Charles Colahan in 1906 took out an American patent for treating the raw stalks with the waste of oil refineries.

About the year 1895 a new method of weighting silk (*the tin-phosphate-silicate process*) was offered to the silk industry. This consists in passing the silk through baths of stannic chloride, sodium phosphate and finally sodium silicate. Experiments show that a weighting of approximately 30 per cent. may be obtained by *one* passage. This new process had not been in use very long before it was observed that silks which had been dyed in pale shades of blue and pink and had then been handled soon developed "red spots." Investigation showed that these were due to the perspiration of the hands having been deposited on the fabric. In 1905 Meister took out a patent for treating silks for the *prevention of these "red spots"* by means of a bath of sulphocyanide. Silks which have been treated in baths of this salt are not sensitive to perspiration, but lack the peculiar "feel" of untreated silk. Of the many processes for *fireproofing* which have been patented the only one which deserves special mention is that by Perkins and Whipp in which cotton fabrics are impregnated with solutions of sodium stannate.

The methods of *waterproofing* fabrics by parchmentizing, rubberizing and Schweitzerizing are at this time too well known to warrant detailed discussion. Suffice it to say that the rubberized cloths have found extensive application for rain garments while the other fabrics are used to some extent by bookbinders.

NOTES ON THE THEORY AND PRACTICE OF EVAPORATION.

(*Continued from vol. clxvi, p. 401.*)

BY

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METHODS OF CONSTRUCTION OF EVAPORATORS.

Materials Used.—By far the large majority of evaporators is made from iron or steel, these being the cheapest materials of construction and the ones on which there is in general the least chemical action. When steel is used it is generally of about the same chemical and physical properties as specified for boiler steel. These properties are as follows:

Phosphorus shall not exceed	.06%
Sulphur shall not exceed	.05%
Manganese shall not exceed	.60%

Tensile Strength	55,000 to 65,000
Elongation not less than	25%

Test specimen should bend flat on itself without cracking.

Any further properties should be those shown in specifications given by American Society for Testing Materials. Speaking broadly it is desirable for this sort of work to have a steel that is tough, ductile and not cold short.

For certain work on very large evaporators, where cast fittings have to be made to stand severe strain, cast steel is frequently used. For example, the steam chests of the horizontal type of apparatus are built with flat surfaces which have to sustain an alternately internal and external pressure of fifteen pounds to the square inch or about a ton to the square foot. In such cases as this where the temperature and pressure may change very suddenly a blow hole or sand hole which sometimes occurs in cast iron would be fatal. The cast steel should conform in properties to the following specifications:

Carbon shall not exceed	.40%
Phosphorus shall not exceed	.08%

Large evaporators for sugar, glucose and certain chemical purposes are built up of cast iron sections entirely as shown in Figs. 4 and 6. Uncertainties arising from the use of cast iron are not so much due to the quality of the material as unavoidable features of foundry work. Hence with cast iron we always allow larger factors of safety. Phosphorus and sulphur should not exceed 0.1 per cent. and the tensile strength should not fall below 20,000 pounds. Cast iron should never be used as a material for the construction of caustic soda evaporators and preferably not in evaporators for any alkaline liquor. In many cases the castings which frequently have small sand holes in the most unexpected and most inconvenient places are corroded by the action of the soda liquor on the silica. Once the leak obtains any size there is no permanent way to repair it but to cast a new section. Also cast iron sections have to be bolted together using some kind of joint packing and there seems to be no kind that is entirely proof against caustic soda. So that the dismemberment of the apparatus may be necessary to put in packing.

Copper is used for the evaporation of tannic acid and extracts where a trace of iron would produce color and in the case of evaporation of milk. Its malleability and ductility make it a rather easy material to work with. Copper and brass are both used as a material for the heating surface in sugar and glucose evaporators and vacuum pans. Aluminum has not as yet come into use for this purpose to any great extent, although in cases where there are no alkalies present its use is perfectly practicable. The evaporator capacity obtained by the use of copper, brass or aluminum is considerably greater than that of iron, steel or lead. Aluminum and brass are able to transmit the heat very nearly at the same rate as copper.

With regard to the tensile strength and resistance to the stresses and wear obtaining in an evaporator, copper and aluminum have usually about the same properties. The tensile strength is usually assumed as 30,000 to 35,000.

It must never be assumed that lead has any resistance to pressure applied in any way in evaporator work unless it be steam pressure in smaller sizes of lead tubing. However, there has lately come into use certain lead lined apparatus, designed to resist the action of certain acid chemicals. The best lead for resistive powers is that containing 5 per cent. to 10 per cent. antimony. However, the welding of this to the steel shell of the evaporator is attended by certain difficulties that make its use unsafe, at least in vacuum work.

Properties of Liquids as Affecting Construction.—In some industries the multiple effect evaporator is among the largest and most expensive of the installations in the factory. Where a large evaporator is to be built for constant use, great attention should be paid to details of its design and construction. The liquids commonly evaporated in any quantity can be divided into two classes: those that foam on boiling and those that do not. It may be said in general that a liquor that entrains (or sprays and passes over with its vapor) does not foam, and a foaming liquor does not entrain. Also it is noticeable that solutions of alkaline reaction tend to foam while those of acid reaction tend to entrain. Most *sugar* juices and glucose come under the latter class. To provide against losses due to entrainment in an evaporator there are to be mentioned such methods as the use of baffle plates, catchalls, and high vapor dome. The so-called film evaporators are subject to the difficulty in this respect that the vapor space allowed is invariably small and from the time a portion of the vapor leaves the boiling solution it carries with it a large amount of spray in suspension in its rapid passage through tortuous channels of small cross-section. The simpler types of evaporator whose construction is more like that of a tank are open to the objection often that the vapor is drawn off from a dome directly over the boiling surface. In these simpler types of evaporators it can be arranged easily to have the sectional area large enough to make the rising of the vapor slow and the height of the dome sufficient to cause practically all the entrainment to drop back. In order not to cause any inversion or possible discoloration in the sugar juices it has been found advisable to have as little as possible of the juice in actual transit through the apparatus. This is accomplished by two principal methods; one by having a rather shallow bank of tubes in which the tubes are packed in the tube sheets as closely together as possible; another by spraying the juice over the heating surface, collecting it underneath and pumping it back again to the spray. This latter method rather subjects the juice to loss from entrainment, unless the vapor dome is extremely high.

In dealing with *soda* solutions the problems arising are of a very different nature from those in sugar work. Under the head of soda solutions we may include among other important cases the evaporation of sodium carbonate, sodium phosphate, pure caustic soda and caustic soda containing brine (electrolytic), black liquor (pulp-mill), mercerizing soda, etc. Except in the case of the more concentrated liquor of the last effect these are all more or less foamy when boiling. The use of baffle plates alone does not accomplish the prevention of loss when foaming takes place. It has been found that the only sure and efficient way to deal with foam, that is to cause it to subside, is to break the individual bubbles by application of heat. Hence the evaporator should be built in such a way that the heating surface is in a high bank above the level of the liquor evaporating. On operating the apparatus it may easily be found by trial what is the proper line of liquid shown in the gauge glass to prevent the foam from rising much above the top of the tubes and yet keep the tubes covered. About the most difficult liquors to handle in this respect are those in pulp-mills or mercerizing plants. In these cases it is necessary to have heating tubes bank almost half the height of the evaporator.

In *salt* industries there are two main difficulties which have to be met by the designer of an evaporator; first the salt has to be removed from the apparatus constantly as it precipitates from solution, second, scale that deposits upon the heating surface has to be removed periodically. In order to render the removal of precipitated salt simple and rapid it has been found best to construct the evaporator with a hopper shaped bottom having either one or two hoppers leading through a valve at their lowest point into a receiver where the salt is separated by draining through a false bottom. Another method consists in precipitating the salt continuously down a barometric leg pipe under the evaporator, draining it and conveying it from the bottom by a closed elevator. This latter method is generally most efficient when working on a very large scale. In salt evaporation work shut-downs are necessary every day and sometimes every half day because of the constant deposit of gypsum upon the heating surface. This happens to such an extent that the evaporative capacity of the apparatus is reduced to a point where it no longer pays to operate. Ready means of access should be provided so that the heating surface may be thoroughly cleaned. The best type of apparatus is that in which the bank of tubes can be quickly and entirely removed from the body of the evaporator by sliding it out the front.

There are certain *acid salts* which require special construction in order to line the evaporator with lead. This lead lining has never been done on a very large scale. In principle it consists in first pickling in sulphuric acid the plates of the machine, these being built with flanges that can be bolted together. The pickled surface is then given a tin coating. A sheet of lead of the proper thickness and size is coated with tin. The two tinned surfaces are laid together and the lead hammered to fit. Then the lead is "sweated" on by heating the iron from the outside to the melting point of the tin plating which is lower than that of the lead. In this way the lead lining becomes attached to the steel by a homogeneous weld. Where the flanges are bolted together the contact of the two lead surfaces generally prevents leakage, but can be made more sure by the process of lead burning.

Other liquids playing a minor part in the evaporator industry are such as *packing house* or *garbage tankage, tannic acid* and *extracts, glycerin, pickle waste,* etc. The details of evaporator construction to suit the properties of these liquids are of a minor character.

Heating Bank Construction.—It is generally most expedient to work out the size of the heating bank from the amount of heating surface determined upon before deciding upon the general dimensions of the shell of the evaporator. The first thing to consider is the bore of tubing to be used. If we are dealing with a vertical type of evaporator where the tubes are expanded into two horizontal tube sheets, the bore of the tubing is determined by the nature of the liquid which is to be evaporated in them and the magnitude of the work to be accomplished. In the case of the horizontal type of evaporator where the steam is in the inside of the tubes and the liquor on the outside, there has been found a ratio of length to diameter for which the steam that condenses within gives a maximum evaporative capacity. If the tubes are too long and constricted, the steam will condense before it can pass to the far end of them; and a certain amount of heating surface is thereby wasted. It is usual to decide upon a certain length and diameter of tubing, however, arbitrarily from experience. It is then easy to decide, from the nature of the solution and taking into account the temperature difference and rate of evaporation, the proportioning of the heating bank. In a vertical effect when the length, diameter and centre line distances are decided it is merely a question of filling a certain number of tubes in the minimum sized circle.

Placing of Heating Tubes.—Tubes may be attached to the tube heads or tube sheets by one of two methods, that of packing them in or expanding them in. To pack the tube in the tube sheet well, the hole in the sheet must be countersunk conically to admit of the forcing in of the rubber packing. This rubber ring is pressed in by a metallic ring so that it is forced against the hole in the tube sheet and against the tube. This ring may be screwed into a thread tapped in the tube sheet or pressed down by a follower which in turn is held to the sheet by a stud bolt. In case a follower with a stud bolt is used it is arranged to hold down either three or eight packing rings simultaneously.

When tubes are expanded into the tube sheet, it is expected that they are to be removed at no time during their life, whereas packed tubes can be easily removed, cleaned and repacked. Tubes expanded into the tube sheets properly make a perfectly steam tight joint for almost any pressure or vacuum. The tubes are extended through the sheets a slight distance and are beaded over and expanded by a special tool for this purpose. The Prosser expander rolls a corrugation in the tube, just inside of the sheet and beads it outside the sheet. In this way the sheet is braced against pressure from within or without. The Dudgeon expander rolls the tube flat against the side of the hole and beads it over on the outside. This method is not as effective in results, but is less of a strain on the metal of the tube.

Calking, Riveting, Bracing, etc.—All riveted seams or joints of an evaporator are made steam tight by calking. This consists in driving the lower part of the planed edge of the plate at a seam forcibly against the plate beneath by means of a calking tool. The acting surface of the tool which is about an inch wide is a rounded edge. It should never be a sharp edge, as the joint might be seriously damaged by actually cutting the metal. The tool is slid along the under plate against the edge of the upper plate and constantly struck with a hammer. A pneumatic calking machine is now used to a large extent. This is somewhat on the principle of a pneumatic drill. Calking of an evaporator must be done far more carefully than is done with a boiler, as it is often necessary to obtain a high vacuum and for this there must be absolutely no leaks of the minutest nature. The seams are nearly always single riveted, both because high pressures, as in boiler work, do not obtain and because every rivet has to be very well calked, as a leak in a vacuum apparatus when detected can be located with difficulty only.

Inside bracing with struts and gussets are used to some extent where flat surfaces of the side of an evaporator are exposed to pressure. These are calculated usually on the assumption that the flat surface takes a pressure, either within or without, of one ton per square foot.

COPPER PRODUCTION IN 1907.

LARGEST DECREASE EVER RECORDED.

The production of copper in the United States in 1907, according to reports returned by the smelters of the country to the United States Geological Survey, amounted to 868,996,491 pounds. The production in 1906, compiled on the same basis, was 917,805,682 pounds, and that of 1905 was 888,784,267 pounds. From the record production of 1906 the output for 1907 shows a decrease of 48,809,191 pounds, or 5.3 per cent. This is the largest actual decrease ever recorded, and is the largest relative decrease since 1886, when the percentage of decrease was 5.5. In 1907, for the first time since 1901. the production was smaller than that of the preceding year, and for the first time since 1872 the production was smaller than for the second preceding year.

The smelter output chosen by the Survey as representative of the copper output of the country is made up of the production of blister copper and of furnace-refined or so-called "ingot copper" of Michigan plus the Michigan copper cast into anodes for electrolysis. It thus consists of the final product of the distinctly smelting operations and does not include the product of any additional distinctly refining process. The figures of smelter production for 1907 are based on direct returns made confidentially to the Geological Survey by all but one of the known smelting companies that handled United States ores, concentrates, or mattes in 1907.

MINE AND SMELTER RETURNS COMPARED.

The quantity of copper given as the output of the *mines* of the United States in 1907, based on reports collected by field agents of the Geological Survey from all mining companies in the country which produced copper during the year, was 847,151,015 pounds, a quantity 2.5 per cent. less than the product of the smelters for the same period. By far the greater portion of the mines' output is treated directly in smelters owned by or having some connection with the mining companies, and this large part of the mine production is reported on practically the same basis as the smelter production. But many of the mine returns are based on the actual or estimated recovery from the ore *shipped from the mines* during the year, whereas the smelter returns indicate the quantity of copper actually *turned out at the reduction works* in that period. In a State like Montana, therefore, operation of the smelters at full capacity for a few days after the mines had begun to reduce shipments would account for a distinct excess in smelter output over that reported from the mines. This fact—that when curtailment of production had once been decided on, the mines were able to execute the plan more promptly than the smelters—is responsible for the greater part of the difference between mine and smelter production of copper in 1907. In 1906, when mine and smelter production were conducted at practically the same rate, returns from the two sources were in very close correspondence, the mine output being only 0.9 per cent. less than the production of the smelters. A second cause of the difference in favor of the smelter figures is the fact that the smelters recover more copper than the mines are paid for. The difference on this account is smaller than that due to other causes, but it is especially important in States like Colorado, where the greater part of the production is from custom ores generally low in copper.

PRODUCTION BY STATES.

Copper was produced in 1907 in 21 States and Territories. The contribution of each to the total production for the year is shown in the following table:

PRODUCTION OF COPPER IN THE UNITED STATES IN 1907, AS SHOWN BY SMELTER AND MINE RETURNS, IN POUNDS.

State.	Smelter returns.		Mine returns.
	Percentage of total.	Quantity.	
Alaska	0.81	7,034,763	6,308,786
Arizona	29.55	256,778,437	254,879,489
California	3.88	33,696,602	28,528,020
Colorado	1.61	13,998,496	7,724,590
Georgia	...	(*a*)	(*a*)
Idaho	1.12	9,707,299	10,890,731
Michigan	25.22	219,131,503	217,767,232
Missouri	....	(*b*)	(*b*)
Montana	25.81	224,263,789	220,108,792
Nevada	.22	1,998,164	1,782,571
New Mexico	1.17	10,140,140	10,990,015
North Carolina	.061	544,040	582,082
Oregon	.059	518,694	544,104
Tennessee	2.24	19,745,119	18,893,115
Utah	7.64	66,418,370	64,256,884
Vermont	.08	696,102	650,425
Virginia	.007	57,008	58,880
Washington	.013	122,263	297,812
Wyoming	.35	3,026,004	2,257,650
Alabama Georgia Maryland	.01	90,655	619,737
Missouri Unapportioned	.15	1,299,043	
	100.000	868,996,491	817,151,015

(*a*) Included with Alabama and Maryland. (*b*) Included with "Unapportioned."

In a report on the production of copper in 1907, which has just been published by the United States Geological Survey as an advance chapter from "Mineral Resources of the United States, Calendar Year 1907," L. C. Graton, of the Survey, presents a detailed discussion of the condition of the industry for that year for the country as a whole and for individual States. Copies of this report may be obtained by applying to the Director of the Survey, Washington, D. C. A summary of the copper production, also prepared by Mr. Graton, was issued by the Survey early in the present summer.

COPPER PRODUCTION IN 1908.

STATEMENT BY U. S. GEOLOGICAL SURVEY SHOWS DISTINCT INCREASE.

To the copper industry of the United States, the year 1908 was a period of gradual recovery from the severe depression suffered in the last part of 1907. Many producers that had greatly curtailed or even suspended production in that year began again to increase output practically at the opening of 1908, and in spite of the low price of the metal, nearly all the important producers of 1907 were in operation throughout most of 1908, and a few new companies began production during the year. The rate of production has been steadily increasing, and is now greater than at any other time in the history of the industry.

The production of copper in 1908 has been ascertained by L. C. Graton of the United States Geological Survey, through personal interviews and telegraphic communication during the last days of the year. Except one small company, all producers of blister and Lake copper have furnished their latest exact figures, in most cases for eleven months together with estimates of their production for the remainder of the year. If these estimates are realized, the production of blister and Lake copper in 1908 from ores mined in the United States, will be greater by about 50,000,000 pounds, or between 5 and 6 per cent., than that in 1907, which was 868,996,491 pounds. It is wholly impossible at this time to publish figures of state production that are reliable, but it may be stated concerning the three great copper producing States, that Arizona and Montana show large gains and Michigan shows little change from 1907. Production of total refined new copper by works in this country cannot yet be given, but probably it will hardly equal the output of 1907, which was 1,032,516,247 pounds.

Based on records of the Bureau of Statistics covering the first 11 months, the 1908 imports of copper in pigs, bars, etc., are estimated at about 160,000,000 pounds and in ore and matte at about 53,000,000 pounds. With addition for copper in pyrite, not included above, the total imports may be estimated as equivalent to about 210,000,000 pounds refined copper, a decrease of about 13 per cent. from 238,031,320 pounds in 1907. On a similar basis the exports of metallic copper are estimated at about 660,000,000 pounds, the largest ever recorded, and an increase of about 30 per cent. over the 508,929.401 pounds exported in 1907.

Stocks of refined copper are still undoubtedly very large. Domestic consumption of new copper will show a decline from the 485,000,000 pounds of 1907. The average quoted price of electrolytic copper at New York for 1908 was 13.20 cents. The price at the close of the year was 14.18 cents.

The prospect is bright at the present for a still larger copper production in the year 1909, but it is evident that the principal producers will, more than in recent years, gauge their operations by the consumption of the metal, which cannot at this time be safely forecasted.

SPELTER PRODUCTION IN 1908.

GEOLOGICAL SURVEY STATEMENT SHOWS A CONSIDERABLE DECREASE.

The production of primary spelter from domestic and foreign ores in 1908 is estimated at 208,000 short tons, worth at the average price, $19,656,000, as compared to 249,860 tons in 1907, 224,770 tons in 1906, and 203,849 tons in 1905. Imports of zinc ore comprised 23,500 tons of duty-free calamine (silicate ore), valued at $222,000, and 30,500 tons of dutiable ore (carbonate and sulphide), valued at $383,000. These imports, which were practically all from Mexico, show an increase of 15,000 tons over the quantities of the corresponding ores imported in 1907, which were 32,624 tons, and 6,472 tons respectively. The exports of zinc ore also show an increase, being 26,108 tons, worth $877,745, compared to 20,352 tons in 1907. The imports of spelter show a decrease of 50 per cent., being 894 tons worth $85,000, compared to 1778 tons in 1907. The exports of spelter show a marked increase, being 2,500 tons, valued at $238,000, as against 563 tons in 1907. The exports of zinc dross were 8,683 tons, in value $483,000, compared to 9,593 tons in 1907.

Prices maintained a uniform, but very gradual ascent throughout the year. The average New York price of prime western spelter for the year was 4.73 cents per pound, the extreme fluctuation in value ranging from 4.32 to 5.15 cents per pound.

The production of spelter from domestic and foreign ores, apportioned according to the States in which smelted, was approximately as follows: Illinois, 49,500 tons in 1908, as compared to 56,056 tons in 1907; Kansas, 98,000 tons in 1908 and 134,108 in 1907; Missouri, 10,000 tons in 1908, and 11,732 in 1907; Oklahoma, 15,000 tons in 1908, and 5,035 tons in 1907; Western, Eastern, and Southern States, 35,500 tons in 1908, and 42,929 tons in 1907.

These figures of production, prepared by Mr. C. E. Siebenthal of the U. S. Geological Survey, are based on reports received from all operating zinc smelters for the first eleven months, with their estimates for December, and are within a very few per cent. of the actual output. The figures of imports and exports are obtained from the records of the Bureau of Statistics, likewise with estimates for December.

REFINED LEAD PRODUCTION IN 1908.

GEOLOGICAL SURVEY ESTIMATES SHOW A SLIGHT DECLINE.

The total production of primary refined lead, desilverized and soft, from domestic and foreign ores in 1908 was approximately 391,000 short tons, worth at the average price $32,844,000, as compared to a production of 414,189 tons in 1907 and 404,699 tons in 1906. These figures are exclusive of an estimated output of 12,000 tons of antimonial lead as against 9,910 tons in 1907. Of the total production, desilverized lead comprised 287,500 tons as against 314,241 tons in 1907. The soft lead production increased to 103,500 tons compared to 99,948 tons in 1907. The increased output of soft lead accompanying a decrease in desilverized lead means apparently that Missouri retains the first place among lead-producing States.

There was 50 per cent. increase in the imports of lead in ore and base bullion, which amounted to 105,000 tons, valued at $4,160,000, as compared to 70,538 tons in 1907. From this it may be inferred that the production of desilverized lead of foreign origin increased considerably over that of 1907 which was 67,423 tons. The imports of refined lead fell off considerably, being 3,000 tons, with a value of $200,000, against 9,277 tons in 1907. The exports of foreign lead (lead of foreign origin smelted or refined in the United States) show a similar increase of nearly 50 per cent., being 75,000 tons, valued at $3,024,000, compared to 51,424 tons in 1907. The exports of lead manufactures remained practically stationary, with a value of about $600,000.

The price of lead started in January with a minimum of 3.625 cents per pound, rising to the maximum figure of 4.60 cents per pound in August, then declining slowly to the close of the year. The average New York price for the year was 4.2 cents per pound.

These figures of production were prepared by Mr. C. E. Siebenthal of the U. S. Geological Survey, from reports and estimates by the desilverizers and the soft lead smelters. They are believed to approximate the actual output very closely. The figures of imports and exports are obtained from the records of the Bureau of Statistics, with estimates for December.

SEASONING AND TREATING TELEPHONE POLE CROSS-ARMS.

There are used every year in the United States about 14,000,000 cross-arms for telephone and telegraph poles. Of these, perhaps one-fourth are now treated with preservatives to increase their durability, and there are at least five plants, at New York City, Norfolk, Va., New Orleans and Slidell, La., and West Pascagoula, Miss., at which cross-arms are treated. Because of their small size as compared with the strength required and the weakening effect of the holes for insulator pins, and their constant exposure to all kinds of weather, cross-arms should receive a thorough treatment. A good treatment with creosote will at least treble their durability.

A large portion of the supply of cross-arms comes from the South; they are sawed from the loblolly or old field pine, of which there is a large quantity throughout this region. This tree grows rapidly, but contains much sapwood, which is difficult to season. It has been said that "loblolly pine sapwood will rot before it will season in the warm, damp climate of the South." While this is probably overdrawn, it is necessary so to pile the cross-arms that the air may circulate freely about them, and to protect them from rain and snow by a roof of loose boards. By laying twenty cross-arms in a tier, two cross-arms at each side and two in the middle set on edge, and allowing a small space between each of the others, which are laid flat, favorable conditions for seasoning are established and no rotting will occur.

Sapwood absorbs preservative so much more readily than heartwood that when both cross-arms in which sapwood abounds and those in which heartwood predominates are treated in the same run the former absorb an excessive amount before the latter have received what they require. This is not only a needless expense, but a detriment, inasmuch as the excess of creosote in the sapwood later oozes out and drips on those who walk beneath. To solve this difficulty, the cross-arms should be sorted in three classes, as sapwood, intermediate, and heartwood, and treated in different runs.

Cross-arms are treated in large horizontal cylinders varying from 90 to 180 feet in length and from 6 to 7 feet in diameter. Into these the arms are run on skeleton trucks, and the doors are then bolted air-tight. Creosote is next run in until the remaining space in the cylinder is filled. Pressure is sometimes then applied by pumps to force the preservative into the wood. In some instances before the preservative treatment the cross-arms are treated to a bath of living steam followed by the drawing of a vacuum, to remove moisture and secure rapid penetration of the wood by the preservative. It is the opinion of the Forest Service, however, that the bath in steam is not necessary or desirable if the arms are properly air seasoned. Other recommendations for seasoning and treating cross-arms, and a discussion of the methods now in use, are contained in Circular 151 of the Forest Service, which can be had upon application to The Forester at Washington.

BOOK NOTICES

WERKSTATT-BETRIEB UND ORGANISATION MIT BESONDEREM BEZUG AUF WERKSTATT-BUCHFÜHRUNG, von Dr. Phil. Robert Grimshaw, Dritte, sehr erweiterte und vollkommen umgearbeitete Auflage. Hannover: Dr. Max Jänecke, 1908. 513 pages, illustrations, 8vo.

In this work, the organization, especially with regard to the keeping of account of cost, with all questions directly and indirectly bearing on this problem, is discussed, principally from a practical standpoint. The subject is profusely illustrated by charts, showing the methods employed by a number of representative firms. It is significant that Dr. Grimshaw has been able to obtain the necessary information almost exclusively from American firms.

The discussion includes not only the systems of keeping account of cost, but also the methods employed for reducing cost, whether by intelligent organization, by the introduction of labor-saving machines or by encouraging the workmen through piece-work and premium plans, through facilitating their work and through avoiding unsanitary conditions.

Those who desire to acquaint themselves with the details of the way in which these problems have been met will find in the book the desired information.

B.

SMOLEY'S TABLES. Parallel Tables of Logarithms and Squares, Angles and Logarithmic Functions corresponding to given bevels, together with a complete set of Five-Decimal Logarithmic-Trigonometric Tables, for engineers, architects and students. By Constantine Smoley, C.E. Fifth edition revised (complete volume). Flexible morocco; 4¾ x 7 inches; 448 pages. Price, $3.50 net. Logarithmic-Trigonometric Tables, separate, $1.50 net. Engineering News Book Department, New York.

Any one who has experienced the tedium of reducing a large number of measurements expressed in feet, inches and fractions thereof to uniform units in decimal notation for the computation of *pons asinorum* problems and then reconverting the result into feet and inches, can properly appreciate the value of a set of tables from which final results may be taken in the required units.

The author frankly points out that his tables are not the first in the field for this purpose, his efforts having been directed to producing tables of superior accuracy, completeness and convenience.

The table of squares is arranged under an argument of feet, inches and thirty-seconds of an inch up to fifty feet. From that value to one hundred feet, the increments are by sixteenths of an inch.

The logarithms of these quantities and their squares are given side by side, forming parallel columns. This arrangement enables a derived dimension and its logarithm, for further computation, to be found in one reference.

The table of angles and logarithmic functions is framed under an argument of inches rise in twelve inches under which are given the corresponding angles and their logarithmic-trigonometric functions.

In a chapter devoted to the explanation and method of using these tables, several examples are given demonstrating the ease with which a triangle may be solved by their use and the results found directly in the required units of feet and inches.

The scope of the book is broadened in the present edition by the inclusion of the usual form of logarithmic and trigonometric tables. These and the tables of squares and angles are published separately to meet the needs of computers whose requirements are fulfilled by either set alone.

For the computations that occur in structural design or in a similar field when economy of time and labor are most important considerations, such a work once available is well-nigh indispensable. The typographical work and binding are of excellent quality.

L. E. P.

The Design of Highway Bridges and the Calculation of Stresses in Bridge Trusses. By Milo S. Ketchum, C.E. Cloth, 6½ x 9 inches. Pp. xxi + 544, 40 tables, 260 illustrations in the text. Price, $4.00 net. The Engineering News Publishing Company, New York.

The commercial value of a structural designer's services is measured strictly by his ability to bring to bear upon a problem the essential requirements for its rapid and economic solution and to eliminate a consideration of features that are of purely academic interest.

In searching to secure the necessary training for qualification in a particular branch of the subject, the student is confronted by a formidable array of technical literature from which he must map out his course of study. A work setting forth the subject by beginning with the elementary principles involved and deductively leading to their practical application and, finally, to a code of commercial practice, is consequently a welcome addition in the field. Professor Ketchum's book is devised along these lines.

The book is divided into three distinct parts:

Part I treats of loadings and stresses in various types of bridges, concluding with a set of twenty-four problems, each illustrated by a stress sheet of a similar problem with different dimensions.

In Part II the calculation of the component members, details and the design of abutments and piers is considered.

Masonry and reinforced concrete arches and culverts are then investigated, followed by a discussion on timber and combination bridges with a chapter on estimates and costs.

Part III consists of a most instructive comparison of the actual with the required carrying capacity of the members of a modern highway bridge.

The work concludes with an appendix giving a full set of specifications for steel highway bridges.

The author's plan of teaching the subject of design by the analysis of an existing structure is one of undoubted teaching value and a conscientious study of Chapter III is a rational step in the study of the subject.

Altogether the work embodies a fortunate blending of the rational with the thoroughly practical.

L. E. P.

Artificial and Natural Flight. By Sir Hiram S. Maxim. Whittaker and Co., London and New York. xv + 166 pages, 95 illustrations, 5s. net.

The author's purpose is clearly expressed in the opening paragraph:— "It has been my aim in preparing this little work for publication to give a description of my own experimental work and explain the machinery and methods that have enabled me to arrive at certain conclusions regarding the problem of flight."

Now that actual flights with heavier-than-air flying machines over considerable distances are of relatively frequent occurrence, the problem of aerial navigation may well be said to have passed the visionary stage. The practical data collected by Mr. Maxim and the results of his experimental investigations constitute, therefore, a particularly timely contribution to the subject.

Any one interested in the development of aeroplane apparatus and propelling machinery should derive material assistance from a study of the record of the experiments and observations of this distinguished inventor.

L. E. P.

THE WONDER BOOK OF LIGHT. By Edwin J. Houston, Ph.D. New York: F. A. Stokes Co., n.d. 349 pages, illustrations, plates, 12mo, cloth, price $1.25.

"The Wonder Book of Light," by Edwin J. Houston, Ph.D., is one of a series of Wonder Books by the same author.

It is a highly valuable book of instruction for young students and should inspire them with greater zeal in their work. Moreover, it is a book which can be greatly enjoyed by more advanced students and those interested in the subjects under treatment. The author has a very delightful manner of treatment of the various laws governing reflection, refraction, color, X-rays and illumination, with numerous practical examples, illustrative of the subjects contained in the book.

The manner of treatment is so clear that it brings the subject before the student in a thorough manner, and the many comments of the author add greatly to its value and interest.

G.

WRECKED ON A CORAL ISLAND. By Edwin J. Houston, Ph.D. Philadelphia: Griffith & Rowland Press, n.d. 416 pages, plates, 12mo, cloth, price $1.25.

"Wrecked on a Coral Island," by Edwin J. Houston, Ph.D., is the second volume of the "Pacific Series," by the same well-known author, and is a sequel to "Five Months on a Derelict," which gives in a graphic manner the adventures and misadventures of three bright and intelligent boys and two experienced sailors on a derelict ship drifting in the ocean currents of the Pacific, upon which, through a disaster to their own vessel, they were compelled to take refuge. After various vicissitudes, many of them thrilling, they were cast upon a coral island in an out-of-the-way part of the Pacific, and "Wrecked on a Coral Island" gives an interesting and instructive account of their life and adventures on the island, as also the structure and formation of such islands of the sea. The book is full of interest and valuable instruction both for young people and also for grown-ups, and makes delightful reading for those fond of the sea and the life thereon.

G.

FRANKLIN INSTITUTE

(*Proceedings of the stated meeting, held Wednesday, December 16, 1908.*)

Hall of the Franklin Institute,
Philadelphia, December 16, 1908.

President Walton Clark in the Chair.

Present, 68 members and visitors.

Additions to membership for one month, 3.

The following nominations were made for officers, managers and members of the Committee on Science and the Arts, to be voted for at the annual election, January 20, 1909:

For President (*to serve one year*)................	Walton Clark.
For Vice-President (*to serve three years*)...........	Jas. M. Dodge.
For Secretary (*to serve one year*).................	James Christie.
For Treasurer (*to serve one year*)................	Cyrus Borgner.
For Auditor (*to serve three years*)................	Wm. O. Griggs.

For Managers (*to serve three years*).

James Christie,
Charles Day,
Morris Ebert,
Persifor Frazer,
Harry W. Jayne,
Lawrence T. Paul,
Horace Pettit,
Otto C. Wolf.

For Members of the Committee on Science and the Arts
(*to serve three years*).

Henric Anderson,
Richard L. Binder,
George Breed,
H. F. Colvin,
Thomas P. Conard,
George S. Cullen,
Charles Day,
J. M. Emanuel,
H. R. Heyl,
John M. Hartman,
George A. Hoadley,
W. N. Jennings,
Harry F. Keller,
Louis E. Levy,
Tinius Olsen,
Chas. E. Ronaldson,
John M. Rusby,
Samuel P. Sadtler,
Paul Thompson,
William J. Williams.

(*to serve two years*)

S. S. Fels,
J. G. Klemm, Jr.,
M. B. Wicks.

(*to serve one year*)

Ernest Fahrig,
Thomas C. McBride.

The paper of the evening was read by Mr. Charles K. Fankhauser, of New York, on the Telegraphone. The speaker described the invention of Valdemar Poulsen, of Copenhagen, Denmark, which is designed to record and store the human voice and other sounds on a metal wire or disc by electro-magnetic action. The sounds so recorded may subsequently be reproduced audibly through a telephone an indefinite number of times.

There being no further business, the meeting adjourned.

Alfred Rigling, *Acting Secretary.*

(After the meeting demonstrations were given of the wire and disc machines, with reproductions of communications over the wires of the Keystone Telephone Company's system.)

SEVENTH INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.

THE Seventh International Congress of Applied Chemistry will be held in London from May 27 to June 2, 1909. The President of Honor is Sir Henry Roscoe, the active President Sir William Ramsay, Mr. Macnab is General Secretary and Messrs. Thos. Tyrer and C. Whitman are Treasurers. Dr. Harvey W. Wiley of Washington, D. C., has been appointed the Chairman of the American Committee.

The Congress is divided into the following sections and subsections. The American Chairmen of the subcommittees who will take charge of all papers and matters relating to the sections to which they are assigned are as follows:

1. ANALYTICAL CHEMISTRY
   Chas. Baskerville, The College of the City of New York.
2. INORGANIC CHEMISTRY AND ALLIED INDUSTRIES
   J. D. Pennock, The Solvay Process Co., Syracuse, N. Y.
3. METALLURGY AND MINING EXPLOSIVES:
   a METALLURGY AND MINING
      John Hays Hammond, 71 Broadway, New York City.
   b EXPLOSIVES
      Chas. E. Munroe, George Washington University, Washington, D. C.
4. ORGANIC CHEMISTRY AND ALLIED INDUSTRIES:
   a ORGANIC PRODUCTS
      Wm. McMurtrie, 480 Park Ave., New York City.
   b COLORING SUBSTANCES AND THEIR USES
      Bernhard C. Hesse, 90 William St., New York City.
5. INDUSTRY AND CHEMISTRY OF SUGAR
   C. A. Browne, 80 South St., New York City.
6. STARCH INDUSTRY:
   a STARCH INDUSTRY
      T. B. Wagner, Heyworth Building, Chicago, Ill.
   b FERMENTATION
      Francis Wyatt, 402 W. Twenty-third St., New York City.

7. AGRICULTURAL CHEMISTRY
   C. G. Hopkins, University of Illinois, Urbana, Ill.

8. HYGIENE, MEDICAL AND PHARMACEUTICAL CHEMISTRY—BROMATOLOGY:
   a HYGIENE AND MEDICAL CHEMISTRY
      Reid Hunt, U. S. Public Health and Marine Hospital Service, Washington, D. C.
   b PHARMACEUTICAL CHEMISTRY
      Joseph P. Remington, 1832 Pine St., Philadelphia, Pa.
   c BROMATOLOGY
      W. B. Bigelow, Bureau of Chemistry, U. S. Department of Agriculture, Washington, D. C.

9. PHOTOGRAPHIC CHEMISTRY
   L. H. Backeland, Yonkers, N. Y.

10. ELECTRICAL AND PHYSICAL CHEMISTRY
    W. D. Bancroft, 7 East Avenue, Ithaca, New York.

11. LAW, POLITICAL ECONOMICS AND LEGISLATION WITH REFERENCE TO CHEMICAL INDUSTRIES
    Chas. B. Dudley, Altoona, Pa.

All who are interested in promoting the applications of chemistry are eligible for membership in the Congress. Those intending to present papers should write to the chairman of the section to which the paper belongs. Papers should be neatly typewritten on thin paper and be in the hands of the Chairman of the American Committee not later than April 1, 1909, in order to be forwarded to London for translating and printing. Those who cannot attend will be amply rewarded for membership by receiving the publications which will be in several large volumes and will contain the latest ideas and discoveries connected with the progress of applied chemistry.

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DEVOTED TO SCIENCE AND THE MECHANIC ARTS

VOL. CLXVII FEBRUARY, 1909 No. 2

MINING & METALLURGICAL SECTION

(Stated meeting held Thursday, November 12, 1908.)

NOTES ON IRON AND STEEL.

BY
BRADLEY STOUGHTON,
Professor of Metallurgy, Columbia University, New York.

Two subjects, which have been kindly suggested by the President of the Metallurgical Section of the Franklin Institute, will be discussed in our talk this evening; not because there is any especial relation between them, or continuity of thought, except in so far as they both deal with iron and steel, but because they represent somewhat more recent developments in the metallurgy of the world's commonest metal. These subjects are: the electrothermic manufacture of iron and steel, and the properties and uses of alloy steels.

THE ELECTROTHERMIC MANUFACTURE OF IRON AND STEEL.

The manufacture of iron and steel through the agency of heat produced by means of the electric current is an industry dating practically only from about the year 1900, although many experimental attempts were made before that time, and especially in connection with the production of ferro-alloys,—that is, alloys of pig iron used chiefly for the manufacture of alloy steels. The

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[NOTE.—The Franklin Institute is not responsible for the statements and opinions advanced by contributors to the Journal.]

advantages of heat produced by means of the electric current over that produced by means of chemical reactions,—that is, from the combustion of fuels,—are four:

1. By means of electrically produced heat almost any temperature within reason may be obtained, and thus may be employed slags whose melting-point is too high for the commoner types of smelting (*e.g.*, slags very rich in lime and with a correspondingly strong affinity for those harmful impurities, phosphorus and sulphur), or ores which make the furnace charge too infusible for coke-smelting (*e.g.*, titaniferous iron ores in which a large amount of wealth is contained, but unavailable, in some of the northern parts of this country and in Canada), or there may be produced alloys too infusible to be made in furnaces heated by means of fuel-combustion (*e.g.*, ferro-titanium, ferro-tungsten, ferro-chrome or ferro-silicon richer than usual in the alloying element).

2. An exactness and nicety in the control of temperature so great that increased facility is given to the control of chemical reactions within the furnace, so that certain combinations of elements in the iron are made possible, and the temperature at which the steel is finished and cast may be more exactly regulated.

3. Freedom of the metal from contamination by certain impurities, such as sulphur, for instance, contained in the fuels ordinarily employed for smelting.

4. The availability of electric heat produced from water power in some localities convenient to ores and fluxes but where coal, coke, gas or oil may be obtained only at great expense.

The chief disadvantage of the electric production of heat for iron and steel smelting is the high cost of the electric current, which depends not only upon the cost of the power to generate it, but also, in several types of furnace, upon the consumption of the high-priced electrodes used to convey the current to and from the metallic bath. If it were not for this disadvantage of high cost, electrothermic smelting might be expected to rapidly replace fuel smelting for many purposes, and, even under the circumstances as described, it gives promise of a bright and important future, although not perhaps immediately.

In the successful types of furnace, the heat is obtained from the resistance offered to the passage of the electric current; those furnaces in which the arc alone is depended upon have not proved satisfactory in practice. In iron ore smelting, carbon is the conductor whose resistance generates the heat; in refining of pig iron,—that is, in steel-making,—it is the melted metallic bath itself through which the current passes.

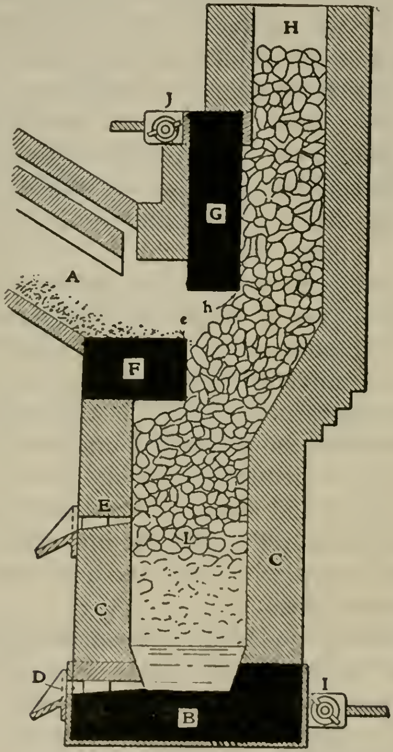
ELECTROTHERMIC IRON ORE SMELTING.

The two most successful electric furnaces for the production of pig iron are those of Héroult and Keller, the latter having been used chiefly for the production of ferro-alloys, although this happens as the result of business arrangements and is not connected with, or dependent upon, the design or operation of the furnace itself. The general principles of operation of both these furnaces are the same: the stack is filled with a mixture of ore, flux and coke, which last-named serves the double purpose of chemically reducing the iron from the ore and of conducting the electric current. In place of coke, charcoal or some other impure form of carbon may be used. An electric current of large volume is caused to pass through the carbonaceous material in the mixture, and the amount of heat generated thereby depends upon the amount of current in proportion to the amount of conductor. As the temperature is raised in this manner, a chemical reaction takes place between the carbon and the iron ore, whereby the iron and oxygen in it are separated. At a higher temperature, the iron is melted and absorbs some carbon and other impurities that have been reduced, while the impurities that are in the oxidized condition unite with the flux and form a liquid slag which floats upon the iron.

The arrangement of the Héroult ore-smelting furnace is shown in Fig. 1. The carbonaceous material is charged into the furnace in lumps at *H*, and, passing downwards, mixes with the ore which enters at *A*. The bottom of the furnace, *B*, is a block of solid carbon which is connected to the source of positive electricity at *I*. The current enters through *B*, passes upward, through the carbonaceous material in the charge, to the negative electrodes, *F* and *G*. As the iron is reduced and melted it collects in a liquid pool in the bottom of the furnace and is tapped when desirable through *D*, together with the slag which floats upon it. There are several Héroult furnaces used for smelting iron ore, and two have been successfully used in this continent.

The Keller furnace has a multiplicity of stacks filled with a mixture of ore, flux and carbonaceous material, as shown in Figs. 2 and 3. These stacks, or shafts, are connected at the bottom by the channel *AAA*. The charge enters at *BB, BB* (refer now only to Fig. 2), and passes downwards in the furnace as smelting progresses. *H* and *K* are blocks of solid carbon; *H* is the positive, and *K* the negative electrode. *E* and *F* are also blocks of solid carbon which are connected by means of a conductor, *G,* passing outside of the furnace. The electric current enters at *H,* passes through the carbonaceous material in the charge to *E,* and thence by means of the outside conductor to *F.* It now passes through the carbonaceous material in the charge of the other shaft to the negative electrode, *K.* The same result in reduction and liquefaction of iron and slag takes place in each

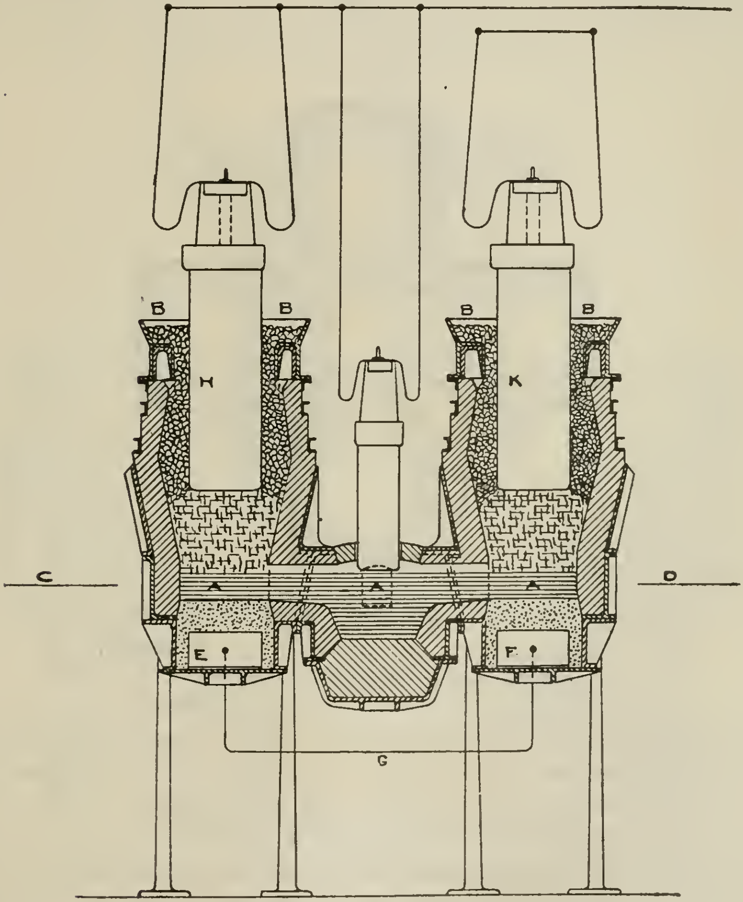
FIG. 1.



Héroult ore-smelting furnace (vertical section).

stack as that described in connection with Fig. 1, and, as the pool of liquid iron collects in the channel *AAA,* it short-circuits the blocks *E-F,* and the electricity passes through this pool instead of through the outside conductor, *G.* In this way the liquid metal is kept hot until it is desired to tap it.

FIG. 2.



Keller electric high furnace with a plurality of open hearths.

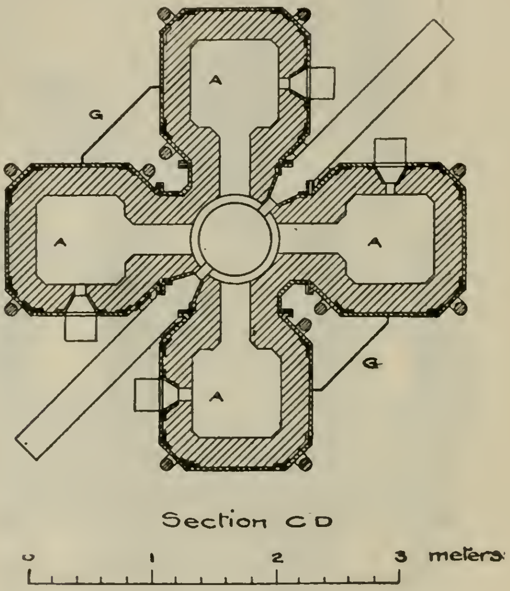
ELECTROTHERMIC MANUFACTURE OF STEEL.

The most important successful electric furnaces for the manufacture of steel are: the Héroult, or open hearth type, the Kjellin-Colby, or induction type, and the Gin, or trough type.

Of these the two former, which represent very different principles, both in the making of steel and in the use and application of electricity, have had the greatest amount of practical application.

The Héroult refining furnace is built very much like an open hearth furnace, as shown by Figs. 4 and 5. The charge, also like that of the open hearth furnace, may be either all pig iron, or, as is more usual, part pig iron and part steel scrap, and it may be piled upon the hearth of the furnace and melted there, or the pig iron may be brought in a liquid condition and poured upon the hearth. The operations of treating and refining are also similar to those of the basic open hearth furnace, the only difference in principle being that the heat is produced by electric means instead of by the combustion of gas. The positive and negative electrodes, *E* and *E*, do not touch the bath, but the current arcs from the positive electrode to the bath, through which it passes and then arcs to the negative electrode. Thus heat is generated both by arc and resistance, but chiefly by the latter. The advantages of the Héroult furnace over the open

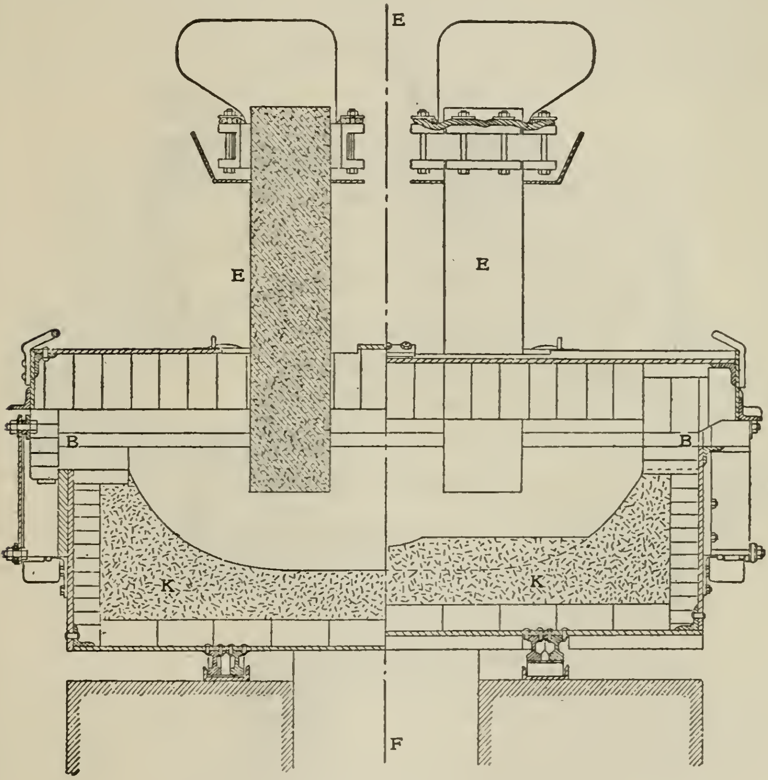
FIG. 3.



Keller electric high furnace with a plurality of hearths.

hearth are that any desired temperature, and therefore a greater variety of slags and fluxes, may be employed, with the consequent facility in removing certain impurities; that the temperature may be more easily controlled, and that the contamination of the metal by impurities unavoidable when heating by fuel combustion, is escaped.

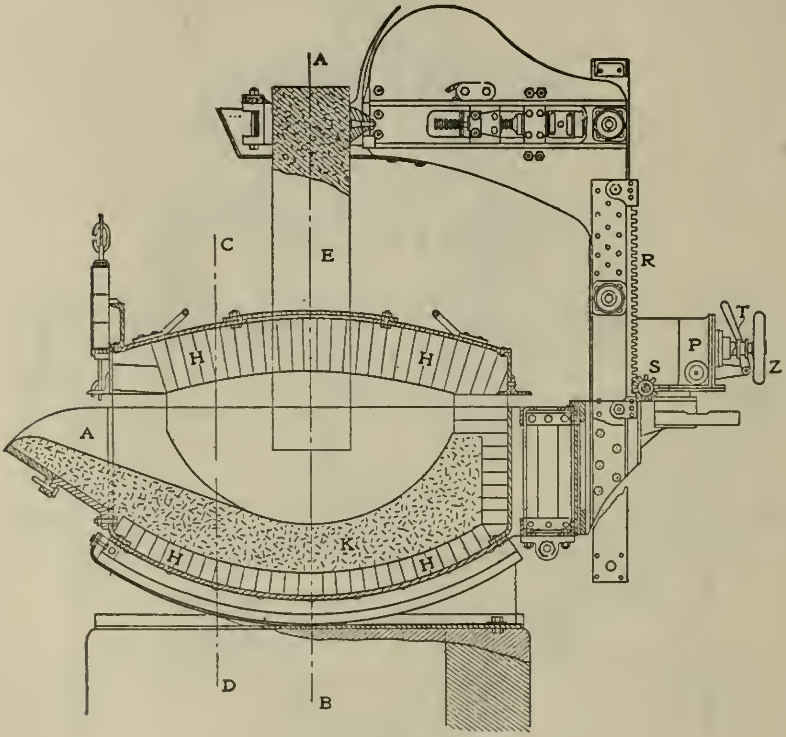
Fig. 4.



Héroult iron refining furnace (longitudinal sections).

The electric induction type of furnace was invented independently by F. A. Kjellin of Sweden and E. A. Colby of America. It is not a refining furnace, but consists essentially of a crucible in which metal may be melted by means of the heat generated by its resistance to the passage of an electric current. Before considering the somewhat complicated electric mechanism of the induction furnace, let us consider the same principle of melting by means of the heat of electric resistance as applied in the Gin furnace (Fig. 6). Here we have a long trough which, for convenience, is doubled back and forth, and which contains the metal that is to be melted. The long, narrow, shallow trough of metal offers a large resistance to the current, and the heat generated thereby raises the bath to the desired temperature.

FIG. 5.

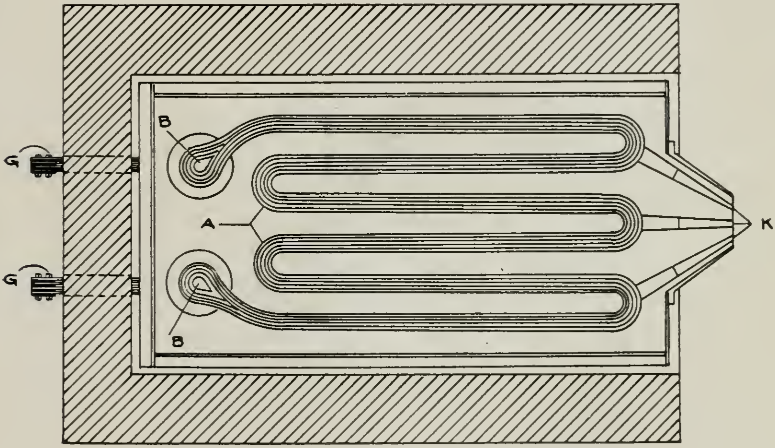


Héroult iron refining furnace (transverse section).

But the great difficulty with the design is that of making the electric connections to the melted bath. Carbon electrodes immersed in the bath at the points *B* and *B* are obviously impracticable, because such an arrangement would result in the expensive electrodes being absorbed and the metal unduly carburized. The difficulty has been met, but apparently not overcome, by making water-cooled electric connections at the points *B, B*.

The characteristic arrangement of the induction furnace is that all electric connections are unnecessary, and thus a great obstacle is overcome. The trough of this furnace is a circle (*B, B,* Fig. 8) moulded in block of fire-clay or similar substance, and covered with several little fire-clay covers (*K,* Fig. 7). This trough is really an annular crucible in which the metal to be melted is placed, after which a current of electricity is set up in it by the induction principle. Referring to Fig. 7, *CCCC* is the core of an electro-magnet, around one leg of which a coil of wire, *AA,* passes. When an alternating current traverses the coil *AA,* it sets up an alternating magnetic field in the core, *CCCC,* and this in turn sets up a secondary electric current in the ring *BB.* In other words, an alternating current in the coil *AA* induces a secondary alternating current in the metallic circuit in the trough *BB,* without there being any metallic connection to it. The disadvantage of employing this principle is that the electric efficiency of the induction is very low, and therefore there is a large waste of current by the furnace, but the many advantages of the design have led to its adoption in several places for the purpose of melting down wrought iron with carbon and "physic" to make the grade of material known as "crucible steel." The cost of making crucible steel by the ordinary process

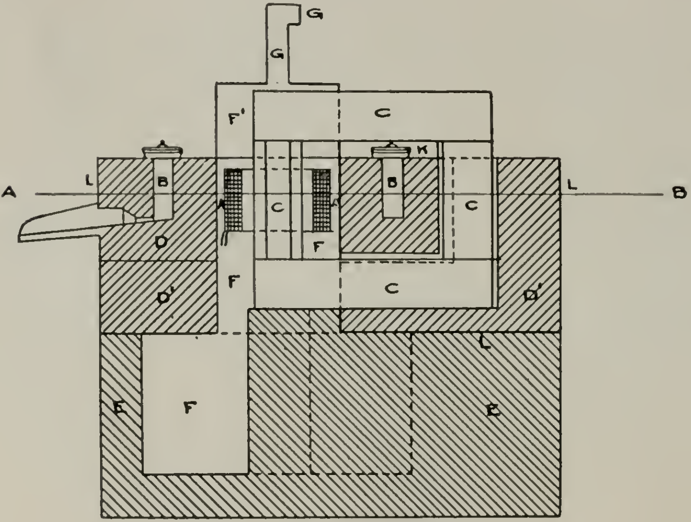
FIG. 6.



Gin electric furnace.

of melting down wrought iron, etc., in clay or graphite crucibles set in a coal fire or in a "melting-hole" heated by regenerated gas and air, or on the hearth of an open hearth furnace, is so great, on account of the short life of crucibles, the waste of heat, and the excessive labor, that the electrically heated crucible of the induction-furnace type can expect to compete in cost, while it has the advantage of being less liable to contaminate the metal with impurities in the fuel or furnace-gases, or in the walls of the crucible. The electric furnace also provides a better regulation of the temperature.

FIG. 7.

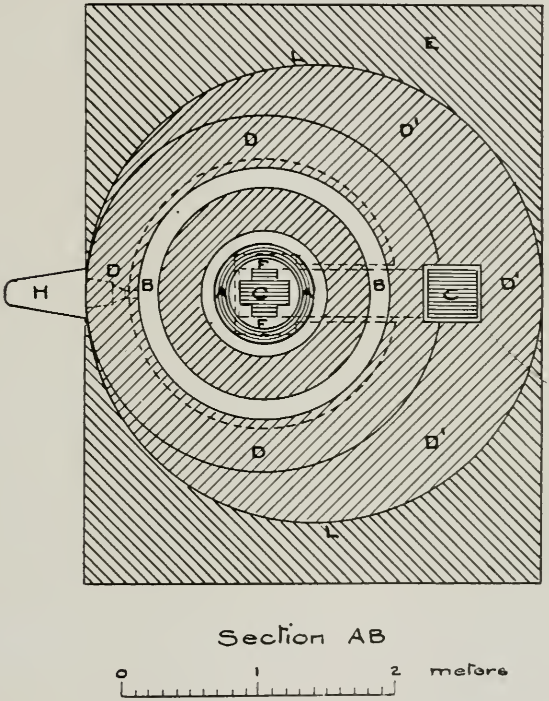


Kjellin furnace.

THE PROPERTIES AND USES OF ALLOY STEELS.

Nickel steel still retains the supremacy among the alloy steels as regards industrial importance and the amount used. Structural nickel steel contains usually about 0.35 per cent. of carbon and 3.50 per cent. of nickel. The presence of this much nickel increases the elastic limit of steel of this amount of carbon by about 50 per cent., while decreasing the ductility only about 15 to 20 per cent., and gives the material about six times the life in resistance to "fatigue." For these reasons it now finds use in the tension pieces of some important bridges, for parts of engines, especially piston rods, links, locomotive side frames and various forged pieces, for shafting, especially marine shafting, for wire cables, for the frames of automobiles, which are now commonly made of this material, etc., etc. For castings, nickel steel has many points of superiority, including greater strength, greater liability to soundness, better crystalline structure, and less liability to checks and segregation. Nickel steel is harder than carbon steel and has a lower coefficient of friction, and for these reasons it has found employment as axles, especially of locomotives and automobiles. The same strength of axle may be obtained in a smaller size, if of nickel steel, and this, because it reduces the area of bearing surface, still further reduces the frictional resistance. The hardness of the material finds use in railroad rails upon curves where the wear is extraordinary, while its greater resistance to corrosion finds use in boiler tubes and gas

Fig. 8.



Kjellin furnace.

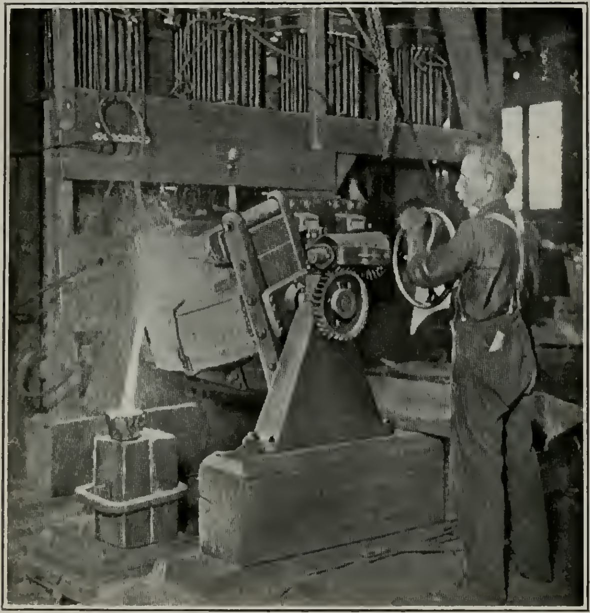
engine valves. For the two latter purposes it is not uncommon to put as much as 30 per cent. of nickel in the steel. The expansion of the common grades of nickel steel is almost the same as that of carbon steel, but this quality is subject to great variation as the amount of nickel increases, and, when we have 36 per cent., it becomes almost zero with the daily changes of atmospheric temperature. Steel of this invariant character is patented under the name of "invar," and is used for pendulums of clocks and such like purposes. As steel measuring tapes for survey work it enables greater speed and accuracy to be attained at once, and permits working in important surveys even when the sun is up instead of during the night. When the nickel is further increased to 42 per cent. we have another patented compound known as "platinite," which has the same expansion and contraction with atmospheric changes of temperature as has glass. It can thus be used for the electrical connections passing through the glass plugs in the base of incandescent electric light bulbs, for which the only material hitherto known was platinum.

Chromium is used very little in steel except in combination with some other element, as nickel, tungsten or vanadium. The most important chrome-nickel steel is that containing 3.25 per cent. of nickel and 1.50 per cent. of chromium, with 0.25 per cent. of carbon. This is the formula of armor plate, and the outside of the plate is afterwards increased to about 2.50 per cent. of carbon by cementation, after which it is hardened with iced brine. The advantage of the chromium in this formula is that it greatly intensifies the hardness produced and also, with the nickel, increases the strength. The steel of armor-piercing projectiles also contains about 1 to 2 per cent. of chromium for the same reasons. Chromium, from 0.20 per cent. upwards, is sometimes put into gears and such like articles that are to be case-hardened, and the combination of chromium and nickel is used in steels for automobile crank-shafts and other articles requiring great strength. Steel with 3.50 per cent. of nickel and about 1 per cent. of chromium, after quenching in oil, or a double heat treatment, will often have well over 200,000 pounds per square inch tensile strength and elastic limit, with an elongation of 8 to 12 per cent. in 2 inches and a contraction of area of 30 to 40 per cent. Three-, four-, and five-ply steel is often made by sandwiching alternate plates of soft steel and of steel containing 1 per cent. of chromium and 1 per cent. of carbon, tying into a "bundle," heating to a welding heat and then rolling down into bars for jails or plate for burglar-proof safes. These bars or plates after heat treatment cannot be drilled through on account of the layers of hardened chrome steel, and cannot be shattered on account of the layers of soft steel.

Manganese steel usually contains about 12 to 15 per cent. of manganese and from 0.70 to 2 per cent. of carbon. It is characterized by great strength and ductility (almost the only material known that has both of these qualities at once) and a relatively low elastic limit. It is hard under all circumstances, so that machining it is difficult, and indeed, impossible except to a very slight extent. It is also difficult and delicate to roll or forge and must usually be cast to the desired shape. When first cooled from the melted state it is not only hard but also very brittle; after reheating to nearly 1100° Centigrade and cooling as rapidly as possible in cold water or an iced mixture, it loses its brittleness and becomes tough and ductile, but still retains its hardness. Another peculiarity of it is that it is non-magnetic. It is used chiefly for articles that require to be hard and resist wear, but do not require much machining, such as railroad frogs and switches, burglar-proof safes, jaws and wearing parts of rock-crushing machinery, railroad rails on curves, etc.

The old "Mushet self-hardening steel," which is still used for machining where heavy, deep cuts are to be made, or hard material, such as armor-plate, is to be finished, but not at a rapid speed of cutting, owes its peculiar property of being hard and remaining hard without any heat-treatment, to the presence in it of nearly 2 per cent. of carbon together with both tungsten and manganese, or else tungsten and chromium. A common formula was: 1.85 per cent. carbon, 9 per cent. tungsten and 2.50 per cent. manganese. At the Bethlehem Steel Works Messrs. Taylor & White experimented with steels of this and other formulæ and discovered a heat treatment which not only increased their toughness but caused them to retain both their toughness and hardness at a red heat, so that they could do their cutting work at speeds so high that the point of the tool became red hot with friction. The amount of work they would do before regrinding was also increased. One feature of the heat treatment they employed was to heat the steel nearly to the scintillating point, and it was subsequently discovered that this was the essential feature to attain the desired result. It was also soon learned that the formulæ of the steels used by Taylor & White could be improved upon, and the steels now employed usually contain well under 1 per cent. of carbon and from 12 to 24 per cent. of tungsten, with only 0.30 per cent. or so of manganese. Sometimes the tungsten is replaced by 10 per cent. or so of molybdenum, or else molybdenum or chromium will be used together with the tungsten. The simplified heat treatment usually consists in heating the steel to about 1100° Centigrade and then cooling it with moderate rapidity, such as leaving it exposed in the open air or holding it in a blast of cold air. The name of "high-speed steels" has been given to these combinations, on account of the great rapidity with which they machine metals.

FIG. 9.



Colby induction electric steel furnace. Reproduced by the kind permission of the American Electric Furnace Company.

Steel containing 4 to 5 per cent. of tungsten and 0.50 to 0.70 per cent. of carbon, heated to 800° C. and quenched out in cold water, makes a more permanent magnet than ordinary carbon steel treated in the same way. The tungsten can be replaced with about 2 to 3 per cent. of molybdenum, and sometimes we add 0.50 per cent. of chromium with either the tungsten or molybdenum, which will increase the permanency of the magnetism but reduce its initial force.

It had always been supposed that the purer the iron the better it was for the purpose of making electro-magnets, but Mr. R. A. Hadfield is the inventor of a steel which gives better results in this service than the purest iron it has been possible to obtain commercially. His steel contains 2.75 per cent. of silicon and the smallest possible amount of all other elements. Before this steel will show its characteristic magnetic properties, which include a high magnetic force, low hysteresis, and moderately high electric resistance (which latter reduces the "eddy currents" that are a source of loss in magneto-generating machinery), it must be subjected to a double heat treatment consisting of first heating to 1070° C. and cooling rapidly and then reheating to 750° C. and cooling very slowly.

The latest development in the line of alloy steels is that of vanadium steels, which in some cases have shown a wonderfully increased strength over carbon steel, and in other cases have proved somewhat contradictory. Nevertheless many engineers and manufacturers have been encouraged to go ahead, and many tons of this alloy have been made and used, while others have waited for further information. It would seem that vanadium is chiefly useful in very small doses,—not over 0.20 per cent. as a rule,—and also in combination with some other element as nickel or chromium. These combinations are particularly susceptible to the benefits of heat treatment, and great strength with relatively great ductility is sometimes obtained.

GROUND WATERS OF THE ATLANTIC COASTAL PLAIN.

INVESTIGATIONS IN PROGRESS BY THE GEOLOGICAL SURVEY.

The United States Geological Survey is making an investigation of the ground waters of the coastal plain of the Eastern and Southern United States, an area in which artesian waters are important in many industries. This investigation, which is under the general direction of T. Wayland Vaughan, includes not only an examination of the geologic conditions and structure that make artesian wells possible in this area, but also determinations of the quality and distribution of the waters and of their adaptability for use for boilers, manufacturing, irrigation, and drinking. This work is being carried on in co-operation with State surveys in nearly all the coastal-plain States fom New Jersey to Texas.

WORK IN TEXAS.

The work in Texas is conducted by Alexander Deussen, of the geological department of the University of Texas, at Austin. The citizens of Texas who are interested in the economic development of the State can be of great service in this connection by sending to Mr. Deussen such data as may be in their possession concerning well logs, analyses of water, and the location, depth, capacity, and quality of wells, and also by furnishing samples of rocks and fossils (shells) taken from wells.

Reports on the investigations in Texas will be issued from time to time until the entire coastal plain of the State has been covered. The area east of Brazos River was the first to receive attention, and surveys are now in progress in the area between the Brazos and the Colorado. The report that will perhaps be of greatest economic value and interest to the citizens of the State will be that dealing with the artesian waters of southwestern Texas—that portion of Texas in which, by reason of its arid climate, artesian water is urgently needed for use in irrigation. The publication of these results should be a great stimulus to immigration and settlement in this new farming district. This work will be undertaken as soon as the other studies have been completed.

The results of the investigations east of the Brazos will be outlined in a paper that will soon go to press, entitled "The geology and ground waters of the coastal plain of Texas east of Brazos River." This report will deal particularly with water conditions but will also form an important contribution to the geology of the district.

PENNSYLVANIA ANTHRACITE.

The following statement regarding the anthracite industry of Pennsylvania has been prepared by Wm. W. Ruley, chief of the Bureau of Anthracite Coal Statistics, of Philadelphia. Mr. Ruley estimates that the shipments of anthracite for 1908 were 64,237,076 long tons, against 67,109,393 long tons in 1907, indicating a decrease of 2,872,317 long tons, or 4.28 per cent. Assuming that the quantity of coal sold to local trade and used at the mines decreased in the same proportion, the total production in 1908 amounted to approximately 73,200,000 long tons, as against 76,432,421 long tons in 1907.

The shipments of anthracite coal for the year 1908, although about three million tons less than for 1907, were nevertheless, next to those of that year, the largest in the history of the trade. A very considerable falling off in the demand was naturally to be expected in view of the depressed business conditions over all the country, and especially in the great manufacturing centres in the East, where anthracite is so largely used; yet the actual results were extremely gratifying, and indicate that, limited as the territory is for the consumption of anthracite, some curtailment in the individual demand was probably to a large extent offset by the increase of population in the anthracite-consuming territory.

About 80 per cent. of all the anthracite shipped is consumed in the New England States, Pennsylvania, New York, and New Jersey, or, in general, along the North Atlantic coast. The fact that the financial depression was probably more marked in this territory than in any other section of the country makes the relatively large consumption even more significant than might appear at first sight. It might naturally be supposed that the shutting down of so many industries and the consequent surplus of bituminous coal would result in a considerable decrease in the use of steam sizes of anthracite in competition with bituminous at the low prices. The facts, however, show a strong demand for the steam sizes of anthracite at prices, generally speaking, better than those ruling in 1907, and reports in the trade indicate that on the restoration of normal conditions the use of small sizes of anthracite for steam purposes, by establishments preferring this coal on account of its cleanliness, will create a demand which it may be rather difficult to supply. The year 1909 will probably witness a consumption of both steam and domestic sizes of anthracite fully up to that of 1907, unless, of course, mining is interfered with by strikes or other extraordinary conditions.

A comparative statement of large and small sizes of anthracite shipped in the years 1907 and 1908, indicating the relative decrease in the production of the steam and domestic coal, is given below:

Year.	Domestic sizes.	Steam sizes.	Total.
1907	57,931,852	9,177,541	67,109,393
1908[1]	55,628,541	8,608,535	64,237,076

[1] December estimated.

THE CEMENT INDUSTRY IN 1908.

REDUCTION IN OUTPUT.

The following statement regarding conditions in the American Portland cement industry during the year 1908 has been prepared by Edwin C. Eckel for the United States Geological Survey.

Detailed figures are not yet obtainable, but an estimate based on the information at hand indicates that the production of Portland cement in the United States was somewhat less than forty million barrels. This compares as follows with the output of recent years:

	Barrels.
1905	35,246,812
1906	46,463,424
1907	48,785,390
1908 (estimated)	40,000,000

The falling off from the output of 1907 was heavy, and is particularly notable because it is the first decrease shown in any year of the American cement industry. The decrease was not uniformly distributed throughout the country, for New York, Pennsylvania, and New Jersey will probably show the highest percentages of loss, while in some portions of the West and Middle West the decrease was relatively slight.

During the year several small companies went into the hands of receivers and the financial stress also led to a change of control in a group of plants operating chiefly in the Pacific States. A fortunate effect of the depression was that it put a stop, temporarily, to the flotation of fraudulent or doubtful cement securities; though it is likely that with improvement in general business conditions promotion schemes will again be taken up on an even larger scale than before the depression.

The year 1909 opens with heavy stocks of cement on hand at most mills, but with good prospects for a steady though slow revival in the cement trade. It is unlikely that this revival will be sufficiently rapid to push mills to their capacity during the year, and it is therefore possible that the high record for output made in 1907 will remain unbroken for another year at least. The total maximum capacity of existing plants is now about 60,000,000 barrels a year.

Despite business depression, or perhaps partly because of it, there have been a number of important technical and industrial developments in the cement industry during 1908, and others are still pending. These will be discussed in the Survey's annual report on cement production, to be issued early in the spring.

SECTION OF PHYSICS AND CHEMISTRY

(*Stated meeting held Thursday, January 14, 1909.*)

SOME NOTES ON QUININE AND ITS ASSOCIATED ALKALOIDS.

BY
DR. E. GOLDSMITH,
Member of the Institute.

THE material from which quinine and its associated alkaloids are obtained is the bark of the cinchona tree.

On the west coast of South America, on the slopes of the Cordilleras de los Andes, Peru, Bolivia, and to some extent in Central America, the trees were found, felled, and stripped of their bark; this was packed into seroons and shipped to the markets of the world.

It seems that in 1640 the cinchona bark became known in Europe, but it took nearly one hundred years before the naturalist traced out the plant from which the bark was derived. Since then a considerable number of species of trees became known, each furnishing its own variety of bark. Botanists visited the localities in the Cordilleras; even Alexander von Humboldt interested himself in the subject and drew and published a map to show the extent and the geographical position of those valuable trees.

It is noteworthy to state, that the trees in question have been nearly exterminated from South American localities. Bogota and New Granada yielded some bark supplies for the market; but the people of South America have ruthlessly destroyed the plants, because they never replanted any of the cinchonas, and consequently lost the market of the world forever.

The supply of the bark is now derived from the cinchona plantations of the East Indies. These are situated on the southern slopes of the Himalaya Mountains, in the Punjab region, where the trees have been cultivated for over thirty years, and the yield of the bark and the alkaloids increased. On the Sunda

Islands, Sumatra and Java, also to some extent on the West India Islands, experimental plantations have shown that the cinchonas may successfully be grown. I am not aware that any of these trees have ever been raised in the United States. The public press in years gone by indicated that in the western mountain regions such cinchona plantations would be started; whether it was ever done is unknown to me.

Several firms in Holland handle the bulk of the cinchona bark and seem to have the monopoly of the trade in it. Since the introduction of the East India cultivated bark the supply of the drug has enormously increased.

For one hundred years or longer the bark as such was dispensed to suffering humanity. However the mixture was prepared, the ugly woody fibre had to be chewed and swallowed. I remember about fifty-five years ago I had to eat some of the ugly stuff to abate a certain trouble. Not long ago I was told by a druggist that certain practitioners adhere still to the old idea of prescribing the bark in powder form.

Not all the cinchona bark offered was accepted for the extraction of quinine it might contain; the bark had to yield more than one-half per cent. of sulphate of quinine, and this was the limit for a great many years during my experience.

It did not pay to buy the poor bark, at least not in this country. Therefore, prior to the purchase of the lots offered, the article had to be sampled and analytically determined.

Quinometry differed with the analyst. My process was as follows:

The samples were finely ground in a mill, well mixed, and one thousand grains' weight mixed with some slacked lime and alcohol and introduced into a steam-jacketed copper apparatus having a false bottom. From the solution the alcohol was distilled and returned over the sample of bark until the extraction of all the alkaloids was completed. The dry mixture of these was then transferred into a four-ounce glass-stoppered bottle, 5 c.c. of ammonia water and sulphuric ether free from alcohol were poured over it, agitated, left standing to settle, and, when clear, the ethereal solution was allowed to run into a porcelain dish. This treatment with ether had to be repeated to secure the complete separation of the quinine from the other alkaloids not so readily soluble in this menstruum. However, it is well known that cinchonidia is also soluble, at least to some extent, in the ether. The ether was allowed to evaporate spontaneously.

The residue is now free from inorganic matter and cinchonia; but it may contain cinchonidia and more or less uncrystallizable colored matters, which have to be separated. In order to accomplish this in a proper manner, the alkaloids have to be dissolved in diluted sulphuric acid. This must be done with care at the boiling point, in such a manner that only a very slight acid solution is obtained. The hot solution is quickly filtered through paper with the aid of the suction pump, concentrated by heating over the Bunsen flame and constant agitation, and the slight excess of sulphuric acid is carefully neutralized with dilute aqua ammonia. If now the correct concentration has been reached, which the analyst can judge better than describe, he will, on further agitating the solution to coolness, obtain a thick and almost complete crystallization of the sulphate of quinine; that is to say, if this salt is present. But, should he observe that a slow mushy mass of a compound drops out, he must suspect cinchonidia sulphate, with or without sulphate of quinine. The massy crystallization was usually allowed to stand a number of hours prior to washing and filtration.

Cold water will take up the coloring matter into solution. The same is the case with the cinchonidia sulphate if present, provided the mass is worked to force these matters to dissolve.

Since sulphate of quinine is very little soluble in cold water, it is comparatively easy to separate it from the other two substances. The washing with small quantities of cold water and forcing the colored solution through the filter paper with the suction pump help to remove the undesirable matter from the sulphate of quinine. When this has been accomplished, the filter holding all the quinine salt is lifted from its support and pressed between absorbing paper nearly to dryness. The complete drying is effected in the steam-heated oven.

After drying and cooling, the sulphate of quinine is removed from the filter and weighed. The alkaloids which the sulphuric ether had not dissolved were converted into sulphates and the clear solution mixed with a slight excess of aqua ammonia to cause them to drop out. They were filtered off, washed, and dried, and finally weighed.

Cinchonia was found, but sometimes also cinchonidia was recognized. If cinchonidia was found and it was required to determine the same quantitatively, I had recourse to the Rochelle salt reaction.

To measure anything correctly is an art which has to be acquired by practice. But, the best analyst can do no more than do his duty faithfully.

How is he, the analyst, made responsible for the sampling which duty is left to the common laborer in the warehouse without any proper instruction? The laborer is not controlled by a superior or by sound common sense. He is ordered to take from every five or ten seroons a handful of bark, put the same into paper, which has been previously marked, and these samples are sent to the buyer for inspection and analysis. This system has been in practice for many years.

Here I may mention my experience with the celebrated calisaya bark, which was supposed to be the best bark for the manufacture of quinine. The statement has often been made in print that from 2½ to 3 per cent. or more of quinine may be relied upon, but I have found that occasionally this very bark is worthless on account of the small quantity of quinine contained therein. To purchase, therefore, any kind of bark on sight and reputation is risky.

The South American bark gave in the average not more than about 1½ per cent. of sulphate of quinine. The cultivated East India bark of the cinchonas has in general a higher percentage of the desirable alkaloids. It seems to me that the formation of sulphate of quinine in the evaluation of the bark is the most practical form in which the determination may rest.

In regard to the so-called manufacture of sulphate of quinine and the separation of the accompanying alkaloids on a large scale, from the time of the second decade of the nineteenth century to the present time, I dare say, the process has undergone a great evolution. The changes in the apparatus used and the introduction of modern machinery have been considerable. I have seen wooden tubs without lining and sometimes lined with sheet lead, used as the apparatus in which the crudely powdered bark was treated with diluted sulphuric acid to exhaust the woody fibre containing the alkaloids. Sometimes hydrochloric acid was preferred for the same purpose, and then the solutions were treated with milk of lime or carbonate of soda to obtain the alkaloids in the solid form.

Experimental work proved that the exhaustion of the bark in an alkaline mixture gave a better and more satisfactory result when alcohol was used as the solvent. To some extent the alcohol could be recovered.

Then followed a great improvement in the fifth decade of the last century in the application of fusel oil as a solvent of these organic bodies. The fusel oil was then not only low in price for a time, but it possesses an oily property admirably adapted to hold the alkaloids in solution, from which they may be readily separated by diluted sulphuric acid.

This property, a trans-solution from one solvent to another, is of a high practical value; because it furnishes at once, with one stroke as it were, a concentrated watery solution of the whole of the alkaloids contained in the cinchona bark.

It is self-evident that this magnificent property, just described, was quickly recognized by those who were engaged in the business of the production of sulphate of quinine. The demand in the markets for fusel oil became in consequence so great that its price rose and here in the United States the supply became inadequate. It became necessary to import it.

Since the amyl alcohol is a secondary product of the alcoholic fermentation, the supply is limited and even the European market has never been overstocked with this useful and interesting solvent.

In 1869 my thoughts were directed to find a substitute for the fusel oil. The cheapness of certain paraffin oils at that time induced me to study their properties as solvents to the quinine group of alkaloids. I observed that certain of those paraffin oils could be utilized for that purpose. I saw that the invention was valuable to the manufacturer of the alkaloids; but my suggestion to utilize paraffin oil was not adopted,—for various reasons,—until a period seventeen years subsequently, when an agent of a paraffin oil producer induced the manufacturer to adopt the oil with which I had experimented, with a result of about one-twentieth of the cost of fusel oil for the extraction of the alkaloids. From this time on, we have the last step in the evolution of the extraction of the alkaloids from the cinchona barks.

You see, therefore, that this work had four periods: the acid period; the ethyl-alcohol period; the fusel-oil time, and finally the paraffin-oil step. It is probable that the paraffin oils are still in use for the general extraction of the alkaloids from the bark.

The next step is to separate the alkaloids from the oil.

If the oily solution is highly concentrated and the temperature is low, it may happen that parts of the alkaloids drop out in a flocculent or sometimes a crystalline form. Now diluted sulphuric acid is added, in which the alkaloids dissolve readily. When this is effected, we obtain two layers, the oily above and the watery sulphate solution below. The oily stratum above is separated from the slightly acid sulphate solution and is ready again for the next extraction, and so on *ad infinitum.*

The acid sulphate solution, which we assume to be rich in sulphate of quinine, now undergoes a fractional precipitation. If we carefully neutralize the solution and agitate, sulphate of quinine becomes insoluble,—that is to say, drops out. This fact, well known for a good many years to the specialist of the article in question, is, so far as I had occasion to converse with chemists, not generally known to my chemical confrères, and for this reason it is put here in evidence. The theory is simple. Since the basic sulphate of quinine is the most insoluble salt of the whole series of alkaloids of the cinchona barks, it becomes evident that, by careful neutralization of the sulphuric acid, the difficultly soluble salt separates first, while the other sulphates remain in solution.

The sulphate salt formed may now be separated from the more soluble parts either by filtration through muslin strainers or the centrifugal machine or the filter press. In either case the dark-colored mother-liquor is separated from the basic sulphate salt more or less completely. If a centrifugal machine or a filter press is used, a washing with cold water may be resorted to with good effect.

Although by the above means the coloring matter is mostly removed from the basic sulphate salt, we obtain usually a grayish or slightly yellow crystalline mass which readily dissolves in boiling water still somewhat colored.

In order to decolorize the solution, recourse is had to fresh fine-ground bone-black. Some manufacturers employ a bone-black freed from the phosphate of lime; others use the ordinary kind. The bone-black is simply mixed into the solution, and the filtration commences either under ordinary atmospheric pressure or with the aid of artificial pressure. These variations are matters of choice, and in various ways it is possible to obtain a perfectly clear solution of high concentration of the sulphate of quinine; but in general the solution has a straw-colored tint from which the white feathery masses crystallize on cooling.

The vessel in which the solution is effected is generally a wooden tank lined with sheet lead. The heating is done either by blowing live steam into the solution directly, or a coil of lead pipe is arranged within the tank through which the live steam under pressure circulates, to cause the solution to boil. The vessels in which the crystallization of the sulphate salt takes place are also built of wood and lined with sheet lead.

If any sulphate of cinchonidia goes into the crude sulphate of quinine, then the mother-liquor from the first fine crystallization contains the cinchonidia salt along with some of the quinine.

The further separation of the various alkaloids from each other belongs to operations which would lead us into a discussion not here intended.

The alkaloids under discussion seem to possess, like the sugars, the property to hydrolize. If the diluted solutions are boiled, to drive away the water,—that is, to concentrate them,—they gradually lose the power to crystallize. This fact being known, diluted solutions are not concentrated by boiling. The alkaloids are either precipitated by carbonate of soda, then filtered off and washed, or recourse is sometimes had to the trans-solution into fusel oil, from which a concentrated acid solution may be obtained at ordinary temperature.

I may state here that in general the separations are effected according to the predominance of any of the alkaloids present in the mixture.

When the solution will not crystallize any more, we have what has been called quinoidine, apparently an amorphous mass. For forty years or more this quinoidine—which had but little sale—was collected.

In 1872 I made an investigation of the apparently amorphous mass, and found that, in reality, a large part of it could be induced to crystallize if treated with Rochelle salt. If the nearly neutral solution of the sulphate of quinoidine be treated with a strong solution of Rochelle salt, a crystalline mixture of tartrates of cinchonidia and quinidine is obtained. To be sure, the tartaric acid was recovered, and the alkaloids could then be brought to crystallize after proper separation and refining.

In 1873, during the panic, the whole of that forty years' collection of quinoidine was worked over. Over two millions of dollars were realized out of it. But since that time all the quinoidine was regularly got rid of by the process above described. Of course, the space gained could be utilized for other purposes.

As stated above, the method of separation of the different alkaloids depends upon the greater or less quantities in which these occur in the mixture. If cinchonia predominates, it must be removed by crystallization or by partial precipitation first; and the same with the others. It follows from this that the workings have to be continually under the systematic control of an expert in this particular line; and, indeed, he who has charge of a large plant to furnish 25,000 ounces of sulphate of quinine per week is pushed to move continually to separate the quinidia, the cinchonidia, and the cinchonia; otherwise the vessels of the plant would soon be all filled to overflowing; which must be avoided.

In 1875 a crystalline mass, supposed to be sulphate of cinchonidia, had not crystallized in the normal form. The crystals were colorless and gelatinous. Such a matter had been recorded before; but no further investigation had been made and no distinct reaction given. It occurred to me to seek for some facts to establish its identity, if possible, and to name it, whatever it might be.

The crystals were separated from the gelatinous mother-liquor. As long as they were moist they were transparent, with a glossy reflecting lustre. Dried in the air between folds of paper, they became opaque and fell to a white powder which seemed to be microcrystalline. The transparent form of the substance is therefore not constant in the air.

The alkaloid may be separated from the sulphate by ammonia. After washing with water and drying we have a white powder.

A hydrochloride may be formed by dissolving the precipitated white powder in hydrochloric acid. The hot concentrated and neutral solution of this hydrochloride on cooling will crystallize in long slender silky prisms; in fact, the crystals extend from end to end of the vessel in which they are formed.

Now, if these crystals be allowed to remain in the vessel during several days, a transformation takes place, such that short, stout monoclinic octahedra make their appearance. In order to see whether the same phenomena would reappear, I repeated the same process again and again with the same result.

As far as I knew, this property of paramorphism, so well defined in this rather rare alkaloid, is distinct from any of the others in the group.

At the time I contented myself to hunt over the records and did not follow the subject further, partly for want of time and partly on account of a promise given not to publish anything observed in the chemical works. I did prepare the gold salts and also the platinum salts of the alkaloid, and, in the determination of the metal contained in each of them, I became convinced that I had found a new alkaloid.

In 1876 a conference took place, in the Main Hall at the Centennial Exposition, between myself and a chemist who worked in the same line and who had made some observations in a similar matter; that is to say, on an alkaloid which, as he expressed himself, gave a gelatinous sulphate. I suggested that he should send a sample of the material to O. Hesse, in Germany. This gentleman had a position in a sulphate of quinine works with the right and liberty to investigate not only but also to publish his results.

Five years afterwards he published the result of his investigation, in which the fact appeared that the alkaloid under consideration was distinct. O. Hesse named it para-cinchonidia. The author made an ultimate analysis of the substance, and reported that it contained 19 molecules of carbon, instead of 20 molecules, which some of the other bodies, as quinine, etc., hold.

It is probable that I was the first to recognize this rather rare new alkaloid, but I do not claim any priority, because I did not publish anything before 1881; I was simply prevented by a promise made to a manufacturer.

The formulas of the foregoing alkaloids are:

Sulphate of quinine, $(C_{20}H_{24}N_2O_2)_2.H_2SO_4 + 7H_2O$
Sulphate of quinidine, $(C_{20}H_{24}N_2O_2)_2.H_2SO_4 + 2H_2O$
Sulphate of cinchonidine, $(C_{19}H_{22}N_2O)_2.H_2SO_4 + 5H_2O$
Sulphate of cinchonia, $(C_{19}H_{22}N_2O)_2.H_2SO_4 + 2H_2O$
Sulphate of para-cinchonidine, $(C_{19}H_{22}NO)_2.H_2SO_4 + 2H_2O$

SECTION
OF PHOTOGRAPHY AND MICROSCOPY

(*Stated meeting held Thursday, January 7, 1909.*)

THE DAGUERROTYPE, THE AMBROTYPE, AND THE PHOTOGRAPH.

BY
WILLIAM O. GRIGGS, M.D.,
Member of the Institute.

THE word 'photograph' is obtained from two Greek words—photos, light, and graphos, to write. Photography is the art of producing pictures by the action of certain sensitive substances under the action of light. It is said to have sprung from the discovery, some 300 years ago, that the luna cornea of the alchemists (fused silver chloride) would darken on exposure to light. Nothing more was known about this until in 1777 Scheele, the Swedish chemist, noticed that the power which produced this darkening resided chiefly in the violet end of the solar spectrum; this led to the use of nonactinic or red light in which to handle the sensitive plates, especially while developing and fixing them. The difficulty of fixing the pictures was one of the early troubles experienced; this was finally overcome by Sir John Herschel, who suggested the use of hyposulphite of soda.

The photographic picture is obtained in the daguerrotype process on polished metal plates, either of silver or of copper coated with silver.

Calotype is produced on paper,
Albumin on a film of albumin on glass,
Collodion on a film of collodion on glass,
Gelatin on a film of gelatin on glass.

The daguerrotype process was discovered by Niepce and Daguerre, and in short is as follows: A silver or silvered copper plate is highly polished and placed in a dark room on a china dish containing iodine. The vapor of this substance combines with the silver of the plate and produces iodide of silver, a substance sensitive to light. This wonderful discovery, like many others, was the result of an accident. Daguerre had iodized some silver plates to use for an experiment he was making and carelessly left a metal spoon lying on one of them; upon raising the spoon some time afterwards, he found its image clearly impressed upon the plate. From this he learned that iodide of silver was sensitive to light, and after a few more experiments the so-called daguerrotype was produced.

One of the first difficulties that Daguerre encountered was to have the plate properly polished. This was finally successfully accomplished by August Brassart, a silversmith of Paris, who sought out Daguerre and volunteered his services. It is stated that when the first successful picture was made, Daguerre embraced his assistant and fainted in his arms. Brassart died in St. Louis, Mo., early in August of this present year (1908) and a short historical notice of him appeared in the *Philadelphia Inquirer* of August 10, 1908.

Tree-frog snapshot, Seeds 26 x plate. By Dr. Wm. O. Griggs.

The next difficulty that beset Daguerre was properly to develop the picture. The discovery which solved this difficulty was also the result of an accident. He had made a number of exposures and was as many times discouraged by his want of success in developing his pictures. One day he placed an exposed plate in a closet, intending at some future time to take it out and clean it and resensitize it. After leaving it there for a considerable time, he removed it, and was very much surprised to find the picture beautifully developed. But as there were a number of articles in the closet he did not know to which to attribute the wonderful result. He then began to remove the articles one by one and after each removal he placed an exposed plate in the closet, and still the development went on. Finally after having removed everything he again placed an exposed plate in the closet and was again surprised to find the picture perfectly developed. After making a critical examination of the interior he discovered that some mercury had been spilled on the floor and rightly conjectured that the vapor of the mercury had caused the much-desired result; and further experiments proved this to be true. The picture was finally fixed or made permanent by dipping it into a weak solution of hyposulphite of soda.

Winona Falls Nos. 1, 2 and 3, Pike Co., Pa. Snapshot, Carbutt's Eclipse plate 27
By Dr. Wm. O. Griggs.

To Giambattista della Porta, a Neopolitan philosopher of the latter part of the sixteenth century, belongs the honor of having been the first to contribute to the optics of photography an apparatus by which the size of the picture and its proper registration on the plate could be controlled. This was called the camera obscura, or camera as we term it at the present time, an article which is so common to you all that it is not necessary to describe it.

There is some controversy about the early history of the daguerrotype. It was so slow a process that it was possible to use it only for still-life pictures until the discovery that bromine used instead of iodine for sensitizing the plates rendered them speedy enough to permit of making portraits. The honor of this discovery undoubtedly belongs to Dr. Paul Beek Goddard, of Philadelphia, as in a paper read by him before the American Philosophical Society in 1843, he described the bromide process, exhibiting at the same meeting a daguerrotype which he said he made by that process in December, 1839. Dr. Goddard was known to be a man of sterling integrity and truthful in his statements. This account is published in the Transactions of the American Philosophical Society, vol. 3, page 180. This society was composed of men of eminence in science and character, who would not allow any statement of a doubtful nature to appear on the pages of their journal.

Winona Falls No. 5, Pike Co., Pa. Snapshot, Carbutt's Eclipse plate 27.

The calotype process was the invention of Mr W. H. Fox Talbot. It consists in spreading on a sheet of paper first a solution of iodide of potassium and then a solution of nitrate of silver; these react and produce iodide of silver in the pores of the paper. The paper is then well washed in water, contained in a porcelain basin, to remove the excess nitrate of silver. If this paper is exposed to light, the iodide of silver will blacken. The picture is fixed by the use of hyposulphite of soda. The calotype pictures are all what are called indirect or negative pictures, and Talbot was the first to use the terms negative and positive.

The albumin process consists in dissolving a small quantity of iodide of potassium in properly prepared albumin obtained from white of egg. This is spread on a well-cleaned plate of glass, the dried glass is immersed in a solution of nitrate of silver, exposed to the light in a camera, and developed in the same way as the calotype; that is, by using a mixture composed of a solution of gallic acid and a weak solution of nitrate of silver to which a little acetic acid has been added; it is then fixed as usual with hyposulphite of soda. The advantages of this process are that the details are finer and the objectionable grain of the paper is avoided. It is not suitable for portraits, as it is not very sensitive, requiring about ten minutes in a good light to produce an impression.

Water lilies from Echo Lake, Monroe Co., Pa. Exposure 1 second, Stanley plate 50.
By Dr. Wm. O. Griggs.

The collodion process, which employs a film of collodion properly treated with the iodides and then immersed in a nitrate of silver solution, has the great advantage of being at least sixty times more sensitive than the albumin process and much easier of execution.

The next successful style of picture after the daguerrotype was the ambrotype, from the Greek words ambrotos, immortal, and typos, an impression. This was made on glass on which a properly prepared collodion had been spread, the lights being represented by silver and the shadows produced by a dark background visible through the unsilvered portions of the glass. The ambrotype collodion was composed of

Collodion	8 oz.
Bromo-iodide of silver	6 dr.
Hydrobromic acid	6 drops

The manner of procedure is to make a bath containing 40 grains of nitrate of silver to the ounce of water. The bromide of silver is made by mixing

Bromide of potassium	80 gr.
Nitrate of silver	80 gr.
Water	4 oz.

Dissolve the salts separately, then mix and wash in three changes of water and two of alcohol, then powder iodide of potassium 1 ounce and dissolve in alcohol 8 ounces and add to the above mixture.

Hydrobromic acid is made by taking

Alcohol (95 per cent.)	4 oz.
Water (distilled)	1 oz.
Pure bromine	1 dr.

Shake well and add to the collodion. The collodion is flowed over the glass plate and the plate dipped into the nitrate of silver bath. It is then exposed in the camera, developed with either gallic acid or sulphate of iron, and fixed in the usual way.

The first photography such as is used at the present day—the making of a negative in the camera first and then printing the positive picture from that negative—was done by what is known as the wet-plate process, so called because the plate was sensitive only while wet. This method was as follows: After cleaning the glass thoroughly it was given a coat of albumin by pouring over the plate a mixture of well-beaten white of egg and water. The plates after having been dried were put away and secured from dust. It was found that the collodion used in the next part of the process flowed more evenly and easily over a plate thus prepared. The collodion was prepared in the usual way by dissolving gun cotton in a mixture of alcohol and ether. The proportions are:

Ether	3 oz.
Alcohol	1½ oz.
Gun cotton	16 grs.
Iodide of cadmium in powder	18 grs.
Bromide of cadmium in powder	6 grs.

This was then flowed over the plate (by pouring it on the middle and then tilting the plate in different directions until entirely covered, when the collodion was poured off from the lower right-hand corner) and after it was set it was lowered into a bath composed of 2 ounces of pure crystallized nitrate of silver and 24 ounces of distilled water. The plate was raised from time to time from the bath and examined; if it presented a greasy appearance or showed lines upon it, it was returned to the bath until it presented a smooth homogeneous surface. It had to be placed in the camera and exposed at once while still wet. The plate was then immediately developed by pouring over it a solution composed of

Protosulphate of iron	1 oz.
Acetic acid	12 drops
Distilled water	1 pint

after which it was fixed in a bath composed of

Hyposulphite of soda	3 oz.
Water	1 pint

This process requires such cumbrous apparatus that it is unsuited to the needs of the present day and is very little used except for lantern slides and window transparencies.

Since the advent of the gelatin dry plate, photography has made wonderful strides both in the picturesque and the useful. One of the good features of these plates is that they can be transported to great distances. They may be developed at leisure even months after having been exposed. Another great advantage over the old wet plate is their great rapidity. Until very quick plates were made it was impossible to correctly picture animals in motion. The first successful pictures of this kind were made by Mr. Muybridge. Some of our recent snapshots of horse-races prove the old idealized pictures of trotting horses to be mere caricatures of the truth, as these old pictures show the horses in all sorts of impossible attitudes. Rapid plates are also of use in photographing lightning flashes correctly—some of Doré's illustrations of lightning in Dante's "Inferno" resemble a zigzag staircase more than anything else. One of the pioneers in making pictures of lightning flashes was Mr. W. N. Jennings, of Philadelphia.

Peters Island, Schuylkill River. Snapshot taken against the sunlight, Carbutt's Eclipse 27
By Dr. Wm. O. Griggs.

The first manufacturer of dry plates in Philadelphia was the late Mr. John Carbutt, a member of the Franklin Institute and one of our colleagues in the photographic section. Dry plates are made in three classes—slow, medium fast, and very fast. The very slow chloride plates are used for lantern slides and window transparencies; the medium fast, for landscapes, machinery, and architectural subjects, etc.; while the most rapid plates are used for portrait and snapshot or instantaneous work, and X-ray pictures.

Window transparencies and lantern slides are made in two ways. One is to place the negative in a window with a sky exposure or to back it up with a ground glass and then to photograph the negative on the sensitive plate in the camera. Another and I think a surer and quicker process is to print the picture on the sensitive plate by contact and then develop it in the usual way. This is done by placing the negative in a printing frame and placing the sensitive side of the dry plate in contact with it in a manner similar to that of printing on paper. The amount of exposure can be determined by experience only, as it varies in duration. If the plate is exposed at a distance of 18 inches from an ordinary 6 feet gas burner the variation will be from 20 to 35 seconds, according to the density of the negative.

The developer which I have found to be the most successful is made after the following formula:

No. 1.

Oxalate of potash	3 oz.
Water	10 oz.

No. 2.

Iron protosulphate	3 oz.
Sulphuric acid	5 drops
Water	10 oz.

Use 3 parts No. 1 and 1 part No. 2. Should the plate develop too fast, add a few drops of a 10 per cent. solution of bromide of potassium.

In making up this developer care should be taken not to forget to add the sulphuric acid to the iron solution and to test it with litmus paper to see that it is strongly acid. If it is found upon mixing the two solutions that a brick-red precipitate is thrown down, the mixture must be thrown away, for if used it would ruin the plate. After being well washed the plate should be fixed in a solution composed of 1 pound of hyposulphite of soda and 1 gallon of water.

The use of very rapid plates with the flash-light has made it possible to picture the inside of mines and other very dark places; and they have proven a boon to astronomers, enabling them to picture the stars with great accuracy. A number of important astronomical discoveries have been made by the aid of photography. Many new stars have been discovered on the negatives that were unknown and invisible to the naked eye or the telescope. Wonderful and valuable pictures of eclipses of the sun, even to the extent of moving pictures, have been made. The transit of Venus has been photographed by its aid, and extra satellites to some of the planets have been discovered. As the earth is constantly in motion a carefully regulated clockwork is attached to the camera in order to keep the celestial object properly registered on the sensitive plate. Another of the interesting and educational features to which photography has been applied are the now almost universal life-motion pictures. Some of them are of course made up to illustrate the subject shown, others showing the various industries and modes of life in this and foreign countries are natural and are not only interesting but also instructive to those whose means will not allow them to travel to distant lands. Another very interesting form of picture is the stereograph. This should properly be made with a pair of matched lenses. A division is placed in the camera, the two pictures taken on the same plate, and after being printed, they are cut apart and transposed, as the lenses reverse everything. This is the ideal form of picture, as it gives the effect of a picture seen with both eyes and everything stands out separately, whereas the photograph taken with one lens presents simply a flat surface. The proper manner in which to take a picture of a flash of lightning is to focus the camera during the day on some distant object, then during a thunder storm at night, if a spot is noticed where lightning-flashes occur quite frequently, place the camera so as to command a view of them, draw the slide out of the plate-holder, uncap the lens and trust to luck; for the capturing of a picture of a flash of lightning is really a matter of chance. Since the advent of balloons snapshot pictures have been used for topographical purposes and also during war times in making pictures of the enemy's position and the arrangement of fortifications and distribution of troops.

X-ray photograph of forward dislocation of the elbow joint, rare form, on X-ray plate.
By William B. Griggs, M.D., Children's Homeopathic Hospital, Philadelphia.

The latest and perhaps the most valuable and humanitarian use to which photography has been applied is in connection with the X-ray work. Here the two most comprehensive sciences, photography and electricity, go hand in hand for the benefit and instruction of humanity. By the use of these two great agents, deep-seated and obscure injuries have been pictured and a correct diagnosis made; bullets and other foreign bodies have been located and their removal made comparatively easy; and recently by the use of very rapid plates and large induction coils instaneous pictures showing the opening and closing of the valves of the heart have been made.

A REVIEW OF THE COAL-MINING INDUSTRY IN 1908.

DECREASE IN PRODUCTION.

From reports received by the United States Geological Survey it might be inferred that a most effective method of conserving the coal resources of the country is to develop a financial panic, for one result of the depression that followed the panic of October, 1907, appeared in decreased production of coal in the United States in 1908—a decrease of 15 to 20 per cent. as compared with the production of the preceding year.

In 1907 the production reached the unprecedented total of 480,363,424 short tons, of which 394,759,112 short tons were bituminous coal and lignite and 85,604,312 short tons were Pennsylvania anthracite. Letters received from State officials and others closely in touch with the coal-mining industry in the several States indicate that the bituminous coal production in 1908 was between 320,000,000 and 330,000,000 tons, or practically 70,000,000 tons less than in 1907.

The railroad shipments of anthracite in 1908 amounted to 64,237,076 long tons, or 71,945,525 short tons, as compared with 67,109,393 long tons, or 75,162,510 short tons, in 1907, indicating a decrease in the shipments of this product, which, except for the very smallest sizes, is now used almost exclusively for domestic purposes, of 2,872,317 long tons, or 3,217,005 short tons. This would indicate a decrease in the total production of anthracite of 3,580,000 short tons.

In the bituminous regions the effects of the panic were most seriously felt in the coking branch of the coal-mining industry, the Connellsville and the Lower Connellsville districts of Pennsylvania, the principal coke-producing centres, reporting a decrease in output amounting to nearly 50 per cent.

In Utah, where the smallest percentage of decrease in coal production is reported, namely, 6 per cent., the production of coke decreased about 60 per cent. The largest percentage of decrease is reported from the southwestern counties of Virginia, where the production in 1908 is estimated at 60 per cent. of that of 1907, all of the decrease being attributed directly to the effects of the panic. The next largest percentage or decrease was reported from Michigan, where the production is stated to have fallen off between 25 and 35 per cent., largely as the result of slackened demand in the manufacturing cities along the Lake front, a slackening due directly to the panic. In a few of the coal-mining States the protracted drought, which began in the summer and lasted well into the winter months, caused some embarrassment. In the Southwestern States—Kansas, Oklahoma, Arkansas, and Texas—the coal production was influenced less by the financial conditions than by the competition of coal with fuel oil and natural gas, which has developed through the bringing in of the mid-continent and Louisiana fields, in addition to the already developed Beaumont district. A short cotton crop and a consequently lessened demand from ginning establishments, and a period of idleness from April 1 to June 15, pending a settlement of the wage scale, also adversely affected coal production in these States. Conditions in the later months of the year showed some improvement as compared with those in the first part, but at no time was there any excess of demand over supply. In the States of the Middle West operations were for a time suspended pending an adjustment of the wage agreement; elsewhere there were no serious troubles from strikes or lockouts. The labor supply was usually abundant, and transportation facilities were adequate for the requirements. It was the general impression at the close of the year that despite the prevailing tone of confidence a sudden return to prosperity was not to be expected, and that a return to normal conditions would be slow and gradual, and not in any sense a "boom."

SIGNIFICANCE OF DRAFTS IN STEAM-BOILER PRACTICE.

INVESTIGATIONS MADE BY THE GEOLOGICAL SURVEY.

Engineers of the United States Geological Survey express the opinion that it is possible to double or treble the capacity of a steaming plant without making any radical changes in furnaces or boilers, the increase requiring that about double or treble the quantities of air be put through the fuel beds and boilers. The basis for this opinion is set forth in a report by Walter T. Ray and Henry Kreisinger, which has just been published by the Survey as Bulletin 367.

This bulletin is announced as the first of a series of two or three on the significance of drafts in steam-boiler practice, the succeeding bulletins to follow the same lines but to be of more advanced character. The conclusions presented are tentative, and are the result of a study of one of the many problems growing out of the general plan of the Survey to increase the efficiency with which the coals of the country are being used. Greater efficiency requires better boiler and furnace design, and means a conservation of the fuel resources of the country.

The experiments reported in Bulletin 367 were undertaken with the object of clarifying ideas concerning the passage of air through fuel beds and boilers. Measured weights of air were passed through two beds of lead shot, in series, one of which remained always the same and represented a boiler, the other being varied as to size of shot and depth of bed and representing a fuel bed. Careful observations were made of the weight of air passing through the beds per minute, and all data were plotted on many charts, so as to permit the study of them from various points of view. A number of laws were deduced bearing on the relative amounts of power required to force air through fuel beds of various thicknesses, composed of various sizes of coal, and through boilers of various lengths and areas of gas passage.

To test the applicability of these laws, they were compared with the results of a number of practical experiments made at the St. Louis fuel-testing plant with boilers of the standard hand-fired Heine type, and the principles developed were also studied in connection with the results of certain locomotive tests made at the Norfolk testing plant of the Survey. These various tests and experiments are fully described.

As a result of these investigations the authors believe it may be possible to raise the rate of working the boiler heating surface to three or even four times its present value. Such an increase would undoubtedly mean new designs of grates, stokers, furnaces, and boilers, especially fitted for high rates of working. Fan equipments designed to supply three or four times as much air under several times the pressure would be provided with more efficient engines—an additional factor favoring high-capacity working.

THE ADDITION OF CARBON TO POWDERS WITH A NITROCELLULOSE AND NITROGLYCERIN BASE.

BY

CAPT. MONNI,

Translated from the *Moniteur Scientifique,* August, 1908,

BY

W. J. WILLIAMS, F.I.C.

The results obtained by the use of the new nitro-powders in fire-arms have caused their rapid adoption by all armies and navies. Generally speaking, these powders consist either of a mixture of nitroglycerin and nitrocellulose or of nitrocellulose alone. It is needless to describe the properties of nitro-powders, for they are well known; it need be said only that from the economic and ballistic points of view, the addition of nitroglycerin offers advantages. But practical use has shown that these powders erode the bore of the pieces to such a degree that after a limited number of rounds they become useless. This harmful effect, which increases with the length of the weapon, is augmented in proportion to the quantity of nitroglycerin contained in the powder, and when it is taken into consideration that the products of the decomposition of these nitro-powders are all the same, the cause of this fact must be sought in the *temperature* of the decomposition of nitroglycerin, which is far higher than that of nitrocellulose. Moreover, the decomposition-products of nitroglycerin contain a great excess of carbon dioxide, which removes carbon from the metal. In view of this rapid attack, the Governments which have adopted powders with a nitroglycerin base, find themselves under the necessity of either abandoning their advantages or eliminating their drawbacks.

Italy chose the second method, and made a series of experiments to attain this end. For ten years I was detached to the Government factory of Fontana Léré and put in charge of the experiments conducted by distinguished chemists. I do not intend to detail all that was done, but I can show the grounds by which I arrived at the solution of the problem.

It is known that the Italian Army and Navy make considerable use of balistite, which is a mixture of equal parts of nitroglycerin and nitrocellulose. This mixture is brought by a special method to a nitration of 12 per cent., which corresponds almost exactly to a 9-nitrocellulose. The respective molecular weights are

$$\text{Nitroglycerin, } C_3H_5(O.NO_2)_3 = 227$$

$$\text{Nitrocellulose, } C_{24}H_{31}O_{11}(O.NO_2)_9 = 1053$$

Balistite then is composed of one molecule of nitrocellulose and 4.64 molecules ($4.64 \times 227 = 1053$) of nitroglycerin.

The equation for the decomposition of nitroglycerin is well known: it is written

$$C_3H_5(ONO_2)_3 = 3CO_2 + 2.5H_2O + 1.5N_2 + 0.25O_2$$

It is different with nitrocellulose—its decomposition varies according to conditions and because it is composed of a mixture of products of higher or lower nitration. The following equation appears to be most in accordance with the facts

$$C_{24}H_{31}O_{11}(O.NO_2)_9 = 8CO_2 + 16CO + 6H_2O + 9.5H_2 + 4.5N_2$$

These decompositions being granted, then the products of the decomposition of balistite are

$$4.64C_3H_5(O.NO_2)_3 + C_{24}H_{31}O_{11}(O.NO_2)_9$$
$$= 21.9CO_2 + 16CO + 19.92H_2O + 7.18H_2 + 11.46N_2$$

or in round numbers

$$22CO_2 + 16CO + 20H_2O + 7H_2 + 11.5N_2$$

CALCULATION OF THE HEAT DISENGAGED AT CONSTANT VOLUME.

Heat of formation of 1 molecule CO_2	94	Calories
Heat of formation of 1 molecule CO	25.8	Calories
Heat of formation of 1 molecule H_2O	58.2	Calories
Heat of formation of 1 molecule $C_3H_5(O.NO_2)_3$	98	Calories
Heat of formation of 1 molecule $C_{24}H_{31}O_{11}(O.NO_2)_9$	609	Calories

Hence the result is

$$22 \times 94 + 16 \times 25.8 + 20 \times 58.2 - 4.64 \times 98 - 609 = 2581 \text{ Calories.}$$

If the gases are produced at constant pressure, then 2581 Calories are disengaged. To find the heat at constant volume, there must be added to this figure the number of Calories equivalent to the work of the expansion of the gas.

L = the work.
$L = pv$ kilogrammetres.
$p = 10335$ kilogrammetres per square metre.
$v = (22+16+20+7+11.5)\ 22.321 = 1707.48$ litres.

$$L = \frac{10.335 \times 1707.48}{425} = 41.5 \text{ Calories.}$$

The sum $2581 + 41.5 = 2622.5$ Calories for a molecular weight equal to

$$22 \times 44 + 16 \times 28 + 20 \times 18 + 7 \times 2 + 11.5 \times 28 = 2112.$$

For each kilogramme of powder then, there are

$$\frac{2622.5}{2.112} = 1242 \text{ Calories} + \frac{1707.48}{2.112} = 808 \text{ litres of gas.}$$

Calculation of the Temperature of Combustion.—Let t be the temperature, q the quantity of heat, and c the specific heat between zero and t°; then

$$t = \frac{q}{c}$$

Mallard and Le Chatelier give the following values:

For CO_2 .... $c = 6.26 + 0.0037\ t$ calories
For H_2O .... $c = 5.61 + 0.0033\ t$ calories
For other gases...................... $c = 4.80 + 0.0006\ t$ calories

If these figures are applied to the quantities of gas given above, we get

For $22CO_2$ .... $c_1 = 22 \times 6.26 + 22 \times 0.0037\ t$
For $20H_2O$........................ $c_2 = 20 \times 5.61 + 20 \times 0.0033\ t$
For $16CO + 7H_2 + 11.5N_2$ .... $c_3 = 34.5 \times 4.80 + 34.5 \times 0.0006\ t$
$c = 415.51 + 0.1681\ t$

Introducing these values into the equation

$$t = \frac{q}{c}$$

then

$$0.1681t^2 + 415.51t - 2622.5 = 0$$

$$t = \frac{-415.51 + \sqrt{415.51^2 + 4 \times 2622.5 \times 0.1681}}{2 \times 0.1681} = 2902^\circ \text{ C.}$$

It remains then to find a means of diminishing the effect of this considerably high temperature. This effect is more intense the longer the gas remains in the metallic tube (bore); that is, the greater the diameter and length.

As a long series of trials has shown, the simplest method is to add a certain quantity of carbon to the balistite, which, at the temperature under consideration, transforms all the carbon dioxide into twice its volume of carbon monoxide. Theoretically, $22 \times 12 = 264$ Gm. of carbon are required to reduce the 22 molecules of carbon dioxide (CO_2), formed on firing 2112 Gm. of balistite, into carbon monoxide (CO). Then the explosion produces

$$(\alpha) \quad 60CO + 20H_2O + 7H_2 + 11.5N_2, \text{ molecular weight} = 2376$$

If it be admitted that the oxygen of the water can also be combined with carbon, then 20 atoms more of carbon can be used and the gases become

$$(\beta) \quad 80CO + 27H_2 + 11.5N_2, \text{ molecular weight} = 2616$$

If the case is studied in detail, the calculation of the explosion is

FOR EQUATION α

Heat disengaged at constant volume for 1 kg. explosive.........716 Calories
Volume of gas produced...925 litres
Temperature of explosion.......................................2278°

FOR EQUATION β

Heat disengaged at constant volume for 1 kg. explosive.........407 Calories
Volume of gas..1011 litres
Temperature of explosion.......................................1565°

Does this reduction of temperature actually take place in practice? I will show by the results of experiments how closely these theoretical forecasts are verified.

But it must be borne in mind that equal quantities of balistite and of these carbonated powders do not possess the same explosive force. They give

$$\text{For balistite} \ldots f_1 = 808\left(1 + \frac{2902}{273}\right) = 9397 \text{ atmospheres per kg.}$$

$$\text{For powder } \alpha \ldots f_2 = 925\left(1 + \frac{2278}{273}\right) = 8639 \text{ atmospheres per kg.}$$

For powder $\beta \ldots . f_3 = 1011\left(1 + \frac{1565}{273}\right) = 6804$ atmospheres per kg.

For a content of carbon increasing up to 19 per cent. (as in formula β) the volume of the gaseous products formed increases, but does not compensate for the diminution of temperature. To obtain the same explosive force the charge of powder must be augmented.

A series of experiments proved this was the case. It is necessary to calculate the charges required to obtain the same initial velocity of the projectile at the muzzle of the gun with balistite containing variable amounts of carbon. The results are

Percentage of carbon in the balistite	Charge	Percentage of carbon in the balistite	Charge
0	100	10	116.5
2.5	103	11	118
5	109	13	122
7.5	112	15	123
8	113	19	137
9	115		

The data were very difficult to obtain for percentages above 15.

Certain calorimetric determinations were made which are only valuable for comparison. Thus it was found

Percentage of carbon in the balistite	Charge	Rise of temperature	Percentage of carbon in the balistite	Charge	Rise of temperature
0	100	45°	10	116.5	35.5°
2.5	103	44°	11	118	34.2°
5.0	109	42.6°	13	122	33°
7.5	112	39°	(1) 15	123	30.3°
8	113	37.6°	(2) 19	137	31°
9	115	36.3°			

It is obvious that the values found for the rise of temperature decrease progressively and in a very notable degree in proportion as the temperature (sic; charge) increases.

It is true that neither the charge nor the rise of temperature follows the percentage of carbon exactly; but that is because in manufacturing on the small scale, it is impossible to avoid all the defects which influence the ballistic properties of the explosive. Moreover, the last two results (1 and 2) do not really contradict each other; if the temperatures are considered in relation to the weights of the explosive which would contain the same quantity of nitrated products, the temperature for 2 would be 29.5°, lower than that found for 1.

In proof of the fact that the carbon actually reacts, as in the equations given, it is well to emphasize the fact that during the explosion there is neither smoke nor residue produced. Hence the inference is strong that carbon determines the quantity and the nature of the products of explosion.

Must it not be concluded from these results that balistite, and all powders which produce a large proportion of carbon dioxide, act upon the steel of the muzzle of the gun by removing its carbon?

To answer this question, an apparatus was constructed, analogous to that described by Vieille (Mém. des poudres et salpêtres, vol. xi) to measure the erosion. Vieille, in his experiments, always used the same weight of powder. But in this way an exact expression of the damage done by different powders cannot be obtained. It is preferable, and more logical, to experiment with such quantities of powder as give the same ballistic effect, while keeping the other factors which may influence the result as constant as possible. Hence the powders are granulated so that the duration of combustion shall be the same for all. The following results were obtained:

	Atmospheres	Erosion
Ordinary balistite	3413	0.3038 Gm.
Balistite with 11.28% carbon	3768	0.3048 Gm.

Vieille found that with the same powder the erosion is proportional to the pressure developed in the gun:

	Atmospheres	Erosion
Ordinary balistite	2162	.3038 Gm.
Balistite with 11.28% carbon	2366	0.1461 Gm.
Ordinary balistite	2313	0.3874 Gm.
Balistite with 8.00% carbon	2323	0.2108 Gm.
Balistite with 11.28% carbon	2543	0.1730 Gm.

It is seen, that in spite of a heavier charge of carbonated products and in spite of higher pressure, the erosion is less.

The following comparative experiments were made:

	Atmospheres	Erosion
Balistite with 8% carbon	1,050	0.0041 Gm.
Balistite with 11.28% carbon	911	0.0031 Gm.
Black powder	1,077	0.0118 Gm.
Rottenciler powder	1,020	0.0100 Gm.
Smokeless powder	1,438	0.0110 Gm.

These results need no comment. But this point may be insisted on; if, as Vieille assures us, it is admitted that erosion is produced in the same manner in the apparatus for measuring the erosion as it is in fire-arms, the results prove that carbonated balistite is the least erosive of the explosives.

But, it may be asked, what guarantees can be offered for carbonated balistite from the chemical, physical, and ballistic points of view? The only answer is that these are the same as for ordinary balistite, *i.e.,* it is easily and conveniently manufactured, it offers considerable resistance to variations of temperature and humidity, and its ballistic effect is constant; its combustion is a little slower. Both in economy and in practical results, it corresponds to what was sought.

My official position prevents my going into detail concerning the experiments made to determine the best proportion of the components, the general properties of the powder, and the method of making it suitable for different weapons. The Italian patent is open to the public and any one can study the process.

An interesting question, from the practical point of view, is the use of carbonated balistite as a sporting powder. In fact its production is one-half more economical than that of the commercial powders made for this purpose, and there is no fear that the guns will be deteriorated.

Those who have used balistite as a sporting powder and have not obtained the expected results, may claim that it would have been just the same notwithstanding the addition of carbon. But it is easy to refute this objection. Once its chief fault, the erosive property, is eliminated, the rest is only a comparatively simple question of granulating the powder.

Carbonated balistite can be sold at a price as advantageous for the merchant as for the manufacturer. It is sufficient to say that the cost of production should not exceed 5 fr. 50 ($1.10), and that the charge is about one-third of the equivalent charge of black powder.

FRANKLIN INSTITUTE

(*Proceedings of the Annual Meeting held Wednesday, January* 20, 1909.)

HALL OF THE FRANKLIN INSTITUTE.

PHILADELPHIA, January 20, 1909.

President Walton Clark in the Chair.

Present 45 members and visitors. Additions to membership since last report 5.

The Annual Report of the Board of Managers, with appendices embracing the annual reports of the several committees of the Board and of the Institute, was presented.

The Tellers of the annual election reported the election of all the candidates nominated at the stated meeting of Wednesday, December 16, 1908.

The President then introduced Mr. Franklin J. Truby, of Chicago, who read a paper on "Automatic Telephony." The speaker described the details of the system by means of lantern slides and a working exhibit of an Automatic Telephone Exchange. After a brief discussion the subject was referred to the Committee on Science and the Arts for investigation and report and the speaker of the evening was tendered a vote of thanks.

Adjourned,

JAMES CHRISTIE,
Secretary.

REPORT OF THE BOARD OF MANAGERS FOR THE YEAR 1908, WITH APPENDICES EMBRACING THE ANNUAL REPORTS OF THE VARIOUS COMMITTEES AND SECTIONS.

To the Members of the Franklin Institute:

The Board of Managers herewith transmits the reports of its Committees on Instruction, Elections and Resignations, Stocks and Finance, Publications, and Sectional Arrangements, and of the Franklin Fund and Building Committee. With the exception of the last named committee, these reports cover a period of nine months only, terminating September 30, which is now the end of the Institute's year.

In connection with the report of the Committee on Instruction, should be noted the steps taken in the spring toward the formation of the Alumni Association of the Franklin Institute. As the actual organization did not occur until after October 1, no further mention of it will be made at this time than to express the hope that it may be of great assistance in aiding the development of our schools, and to state that steps should be taken to utilize the Alumni in the work of the Institute.

The financial condition of the Institute has been greatly improved during the year, and all obligations are being promptly met.

The most important event of the year is shown in the report of the Franklin Fund and Building Committee, to wit: the securing of the Franklin Fund from the Board of City Trusts. This fund, with the subscriptions received by the Committee, forms the Franklin Institute Building Fund, which on December 31 amounted to $322,779.46, and is held by the Board of City Trusts for the use of the Institute in erecting its new building. If to this is added the amount of money still owing the Committee and the value of our present building, about $400,000 is shown as available for building purposes. It is hoped that during the coming year an appreciable addition to this sum can be effected, and to this end the aid of every member of the Institute is solicited. As the Committee states, the delay in fixing the exact line of the Boulevard has prevented a definite selection of a site for our new building. When this obstacle has been removed, every endeavor will be made by the Committee toward the speedy procuring of the new home that will enable the Institute to carry forward under favorable auspices the varied activities for which it has been so well known in the past.

The resignation of Dr. Wahl as Secretary has left a vacancy that will be hard to fill. The Institute has been very fortunate in securing the services of Mr. Christie, pending the selection of a permanent Secretary. The following resolution has been adopted by the Board of Managers to mark their appreciation of Dr. Wahl's career of service and accomplishment:

Resolved, That the resignation of Dr. William H. Wahl as Secretary of the Franklin Institute, having brought a termination to the faithful and unremitting service which he has rendered in that capacity through more than a quarter century past, the Board of Managers of the Institute enter upon its minutes this acknowledgment of Dr. Wahl's successful efforts in the furtherance of the Institute's work and this expression of regret that the condition of his health has appeared to necessitate at least a temporary cessation from his labors.

In the organization of the scientific sections of the Institute, in the promotion of its lecture courses, in the enlargement of its schools, and in the editorial direction of its Journal and other publications, Dr. Wahl has performed a distinguished part in the activities of the Franklin Institute, and left a lasting impress on its history.

As a mark of appreciation of Dr. Wahl's services as Secretary and as a member of this Board, this minute is ordered to be suitably engrossed for presentation to Dr. Wahl and to be published in the Journal of the Franklin Institute.

During the year, the Board has lost by death Mr. Jawood Lukens, who has served since 1903, and Mr. Stephen Greene, whose service dates from 1898. Suitable minutes will be prepared to form part of the records of the Board. The Board has also lost by resignation Mr. Thomas P. Conard, who became a Manager in 1896. The Board desires here to bear testimony to the work done by these men, both as members of the Institute and of the Board, in furthering the interests of the Institute.

For the Board of Managers,

WALTON CLARK,
President.

PHILADELPHIA, January 11, 1909.

REPORT OF THE COMMITTEE ON INSTRUCTION FOR THE YEAR 1908.

To the Board of Managers:

The plan of conducting a course of popular science lectures in the Building of the Young Men's Christian Association was temporarily abandoned during the year. In place of the regular course of about twelve lectures, only one-half that number was announced; three were given during the fall of 1907 and three during the spring of 1908. These lectures were delivered in the Institute's hall, and, while the attendance was quite satisfactory, arrangements have been made to continue these courses in the new hall of the Young Men's Christian Association during the present season. As in previous years the speakers received no compensation.

The schools of the Institute have been fairly well atended, and the business depression of the year has not had any great effect on the enrollment. A change in the management of the School of Machine Design has been effected, and the founder of the school, Mr. Lucien E. Picolet, has been secured and will take charge as Director.

The attendance at the spring term (1908) of the schools was as follows:

Drawing School	97
School of Machine Design	38
School of Naval Architecture	7
Total	142

Respectfully submitted,

ALFRED RIGLING,
Acting Chairman.

PHILADELPHIA, PA., January 13, 1909.

REPORT OF THE COMMITTEE ON ELECTIONS AND RESIGNATIONS OF MEMBERS FOR THE YEAR 1908.

To the Board of Managers:

The Committee on Elections and Resignations beg leave to state, that the efforts of the Board have resulted in securing 28 resident members, 11 non-resident members, and 2 life members.

During the same period resignations were presented and accepted by the Board of 18 members, making a net gain of 23 members.

Respectfully submitted,

ALEXANDER KRUMBHAAR,
Chairman.

PHILADELPHIA, PA., January 13, 1909.

REPORT OF THE COMMITTEE ON STOCKS AND FINANCE FOR THE YEAR 1908.

To the Board of Managers:

FINANCIAL STATEMENT.

January 1 to September 30, 1908.

Property and Funds—		
Building and Land, 13-17 S. 7th St.	$44,000.00	
Library	100,000.00	
Apparatus, Collections, and Models	5,022.49	
Investments not held for Trust Funds	2,100.00	$151,122.49

Funds held by Board of Trustees—	Principal.	Unexpended Income.	
General Endowment Fund	$51,350.50	$220.00	
Building Fund	2,685.67	65.60	
E. M. Graff Fund	14,092.12	23.48	
Journal Endowment Fund	138.00		
M. Carey Lea Fund	2,000.00	150.66 (credit)	
Edward Longstreth Medal Fund	1,000.00	288.76	
J. T. Morris Memorial Fund	5,056.25	542.22	
Special Endowment Fund	44.51	657.64	
Potts Library Fund	952.50	14.08	
Potts Medal Fund	1,000.00	26.33	
Funds held by Board of Managers—			
B. H. Bartol Trust Fund	1,000.00	77.50	
Boyden Premium	1,000.00	370.71	
H. W. Jayne Library Fund	500.00		
B. H. Moore Memorial Fund	15,000.00		
New Building Fund	5,360.08*	100.00	
New Building Endowment Fund	115.00		
Endowment Fund, Memorial Library	1,000.00†	26.03	
Funds held by Board of City Trusts—			
Franklin Fund	149,630.74		
Elliott Cresson Fund	1,000.00	3,433.43	
Total Funds	$252,925.37	$5,695.12	$258,620.49
Grand Total			$409,742.98

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* $4863.50 of principal merged with general funds of the Institute.

† Entire principal and income merged with general funds of the Institute.

LIABILITIES.

Certificates of Stock—			
First Class	$36,140.00		
Second Class	1,130.00	$37,270.00	
Mortgage on Institute Building (held by Trustees as investment for Funds)		5,075.00	$42,345.00
Bills Payable—			
Girard National Bank		$3,000.00	
Western Saving Fund Society (secured by collateral)		2,100.00	
Franklin Fund and Building Committee		10,000.00	
Loans contracted in 1902 to meet deficit, notes for which are still held by original payees		2,150.00	
Loans contracted in 1902 and 1903 to meet deficit, the notes for which are now held by Building Committee		3,150.00	20,400.00
Life Memberships (owed to Board of Trustees)			3,835.00
Accounts Payable			1,433.83
Unearned Income—			
Advance Dues		$143.32	
Advance Tuition		674.50	817.82
Grand Total			$68,831.65

INCOME AND EXPENSES.

Applicable to the Nine Months ending September 30.

INCOME.

Dues	$6,727.44
Initiation Fees	55.00
General Endowment Fund	1,514.45
Estate of Robert Wright	1,000.00
Donations	1,000.00
Income from Investments	70.50
Miscellaneous	12.69
Membership Badges	7.00
Instruction Tuition Fees	1,124.71
Library, Books, and Periodicals	* 1,604.72
Publications: Subscriptions and Sales	1,171.13
Advertising	1,725.73
Total	$16,013.37

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* Due to crediting this account with $2806.93, unexpended income of Bloomfield Moore Memorial Fund.

EXPENSES.

Building: Wages	$660.65	
Repairs and Maintenance	569.74	
Heat, Light, and Power	472.81	
Taxes, Water Rent, and Insurance	428.66	
Miscellaneous Supplies and Expenses	408.02	$2,539.88
Elections and Resignations		167.20
Instruction		934.58
Library: Salaries	1,235.25	
Books and Periodicals		
Miscellaneous Expense	708.23	1,943.48
Meetings: Printing	103.95	
Miscellaneous Expense	158.67	262.62
Office and General: Salaries	2,694.59	
Office Expense	531.93	
General Expense	302.56	3,529.08
Publications: Printing	2,427.03	
Engraving	389.76	
Miscellaneous	489.60	3,306.39
Interest and Discount		151.07
Science and Arts		136.37
Sections		181.31
Interest paid John T. Kille on donation to General Endowment Fund		200.00
Total		$13,351.98
Net Income		2,661.39

As is seen by the financial statement above, the fiscal year of the Institute now ends on September 30, thus becoming coterminous with the membership year. Therefore, the statement embraces a period of nine months only.

During this period the Institute received funds as follows: The General Endowment Fund has been increased $400 through the receipt of two life membership fees. Through the will of Elizabeth M. Graff, a sum of $14,092.12 was given to be used to perpetuate "the memory of Frederic Graff in a building or some other substantial manner." Through the will of Howard N. Potts, the sum of $952.50 was given as a library fund, the interest to be used in the purchase of books, and the sum of $1000 was given, the interest to be used for a gold medal to be awarded for distinguished work in science or the mechanic arts. Through the Franklin Fund and Building Committee, the sum of $149,630.74 has been turned over to the Board of City Trusts to form the beginning of the Franklin Fund, which will be devoted to a new Institute building. Through this Committee also, $115 has been received, forming the nucleus of a New Building Endowment Fund.

By a resolution of the Board of Managers, the Building Fund and Special Endowment Fund, held by the Board of Trustees, and the New Building Fund, held by the Board of Managers, were assigned to the Franklin Fund and Building Committee, to be merged in the Franklin Fund, and a portion of the $149,630.74, above mentioned, consisted of securities belonging to these funds. Ultimately these funds will be entirely merged in the Franklin Fund.

The amount owed by the Institute is great, but it is believed that in future current receipts will be in excess of expenses, and each year will show a reduction in this indebtedness. For 1908, only $5,100 of the Bills Payable drew interest. In 1909, $15,100 will draw interest.

Respectfully submitted,

WALTON FORSTALL,
Chairman.

PHILADELPHIA, PA., January 11, 1909.

REPORT OF THE COMMITTEE ON PUBLICATIONS FOR THE YEAR 1908.

To the Board of Managers:

The Committee respectfully reports that it has secured necessary copy to enable the continuation of the publication of the Journal, and maintain the standard of the same.

The contract for printing the Journal has been continued to this time as of last year. The Committee also beg leave to state, that they have been able to secure some new advertisements, and have further prospects of securing still more.

Respectfully submitted,

HARRY W. JAYNE,
Chairman.

PHILADELPHIA, PA., January 13, 1909.

REPORT OF THE COMMITTEE ON SECTIONAL ARRANGEMENTS FOR THE YEAR 1908.

To the Board of Managers:

During the past nine months there were held 17 meetings of the Sections, all of which were devoted to the presentation of papers on scientific and technical subjects. The greater number of papers and a great deal of the material printed in the Journal is derived from this source.

The work of the Sections was divided up as follows:

Section of Physics and Chemistry	2	meetings.
Electrical Section	4	"
Mining and Metallurgical Section	5	"
Mechanical and Engineering Section	3	"
Photographic Section	3	"
Total	17	"

Your committee wishes to express its appreciation of the services of the lecturers, professors and the Section officials in assisting to make these weekly meetings attractive and successful and regret that many of the discourses are not as well attended as they should be.

Respectfully submitted,

JAMES CHRISTIE,
Chairman.

PHILADELPHIA, PA., January 13, 1909.

REPORT OF THE CURATORS FOR THE YEAR 1908.

To the Board of Managers:

The Curators beg to report that during the past year the Electrical wiring of the Building has been completely renovated. The condition of this work, which was done from time to time and without critical inspection, was objected to by the Underwriters Association. This work incurred considerable expense but is now entirely satisfactory to the Underwriters.

The roof, which has always been a source of some trouble, has been repaired and repainted thoroughly and there is some additional painting to be done which will be completed in the spring; we have the material for it on hand.

The stove in the lecture room has been removed and steam pipes replaced instead for heating purposes and other radiators have been repaired.

A few new tools have been secured to facilitate repairs and much of the inflammable material heretofore stored in the basement has been removed. The basement is gradually being put into better shape.

Respectfully submitted,

CHAS. E. RONALDSON,
JAMES CHRISTIE,
Curators.

PHILADELPHIA, PA., January 18, 1909.

REPORT OF THE FRANKLIN FUND AND BUILDING COMMITTEE FOR THE YEAR 1908.

To the Board of Managers:

Your Committee begs leave to report that the agreement between the Franklin Institute and the City of Philadelphia, Trustee, has been completed by the payment on Dec. 31, 1908, of the sum of $50,000.

During the year the two properties at the S. E. Cor. of 16th & Arch Sts. have been purchased and transferred to the City of Philadelphia, Trustee for the Franklin Institute, and in addition to this amount $100,000 and more has been transferred, completing the agreement with the Board of Minor City Trusts whereby the sum of $125,000 and upwards was set aside for the use of the Institute in erecting a new building.

The account of the Treasurer of the Franklin Fund and Building Committee, Dec. 31, 1908, shows a total amount of subscriptions of $200,572.75, and amount paid on account of subscriptions to Dec. 31, 1908, $189,012.75, leaving a balance of unpaid subscriptions of $11,560.

A number of the subscriptions forming this balance are made up of notes of the Institute transferred from subscribers to the Franklin Fund and Building Committee and held by the said Committee.

The account of the City of Philadelphia, Trustee, has been submitted, and the Franklin Institute Building Fund is credited with $322,779.46, including the money transferred to the Trustees by the Institute, the amount of the Franklin Fund and the accumulated interest to date.

Your Committee has not as yet selected an architect, nor has it undertaken to make any plans in regard to the selection of a site upon which to erect the new building. The Boulevard line extending from the City Hall to Fairmount Park has not as yet been settled. The City Park Association has presented a plan changing the line considerably so as to bring the City Hall tower in a line with the centre of the Boulevard.

The new line cuts through the property owned by the Institute and the property adjoining, upon which we have an option, to such an extent that if this line is adopted no adequate building can be erected on the S. E. Cor. of 16th and Arch Sts. If the plan is eventually adopted other nearby sites will have to be considered, and as soon as the Boulevard line is finally fixed upon your Committee will act accordingly.

Respectfully submitted,

HENRY HOWSON,
Chairman.

PHILADELPHIA, PA., January 13, 1909.

REPORT OF THE LIBRARY COMMITTEE FOR THE YEAR 1908.

To the President and Members of the Franklin Institute:

The Committee on Library respectfully submits the following report:

The additions to the Library during the nine months ending September 30, 1908, comprised 2301 titles.

The new acquisitions include:

1010 bound volumes,
242 unbound volumes,
1042 pamphlets,
3 photographs,
2 engravings,
1 manuscript,
1 drawing.

These accretions were derived from the following sources:

40 through the Bloomfield Moore Fund,
12 through the Memorial Library Fund,
8 through the M. Carey Lea Fund,
38 from the general Library appropriations,
473 through the binding of periodicals,
40 through the Journal of the Institute,
3 through the exchange account,

and the remainder through deposits from the Federal and State Governments, through contributions from societies and institutions at home and abroad and through gifts from individual donors. Especially notable contributions were received from:

Drs. Wm. H. Greene, Samuel C. Hooker, Edwin J. Houston, Charles S. Jack, Harry F. Keller, Henry Leffmann, and Paul J. Sartain; Mmes. M. C. G. Canby, Samuel C. Hooker, L. K. Perot, and M. Russell Thayer, and the Messrs. H. M. B. Bary, John E. Carter, George S. Cullen, Carl Hering, E. Hunn, Strickland L. Kneass, Louis E. Levy, Charles S. Linch, T. C. McCollom, Edward S. Miles, and Lewis S. Ware, and from The Royal Technical High School of Karlsruhe; the New York State Library, The Pennsylvania State Library, from the Librarian of the University of Texas, and from the United States Government.

The present contents of the library are as follows:

62827 volumes (bound and unbound),
45955 pamphlets,
2911 maps and charts,
782 drawings and designs,
1305 photographs,
192 newspaper clippings,
34 manuscripts.

A total of 114006 titles.

The following number of duplicates are on the shelves:

571 bound volumes,
368 unbound volumes, and
165 numbers of periodicals.

BINDING.

Binding and re-binding were effected during the past year as follows:

496 volumes of completed serials,
59 paper-bound books,
4 re-bindings.

PAMPHLETS.

The condition of the pamphlet collection remains unchanged. The pamphlets are stored on the first floor of the building, where they are properly preserved though unavailable through lack of classification. Many of these pamphlets are of unquestionable value, and it would be advisable to start the work of cataloguing as soon as possible, as it will take several years to complete it.

EVENING ATTENDANCE.

The Library was open on thirty (30) evenings during the past nine months with a total attendance of 170 visitors.

The number of those using the reading room was greatest in January, followed by the month of April; the smallest attendance was during the month of February.

UNION LIST.

The Index to periodicals in Libraries, in and around Philadelphia, was issued during the year, and we received the 25 copies which the Institute subscribed for. The excess copies are offered for sale and can be had by applying to the Librarian.

PUBLIC DOCUMENTS.

Arrangements are being made to dispose of all the Public Documents which are now being received and for which we have no use, to the Free Library of Philadelphia.

These books comprise a large proportion of the documents which we receive, and occupy a very large portion of our limited space of shelving.

The elimination of this material will enable the Library to retain a complete set of the scientific documents to which we can refer when necessary, and this will give us shelf-room for a great many volumes.

We again call attention to the fact that the care of the books is growing more serious from year to year. The stack which was built ten years ago is filled, and it is difficult to know what to do with the new books which are being constantly received.

Respectfully submitted,

Chas. E. Ronaldson,
Chairman.

Philadelphia, Pa., January 11, 1909.

REPORT OF THE COMMITTEE ON MEETINGS FOR THE YEAR 1908.

To the President and Members of the Franklin Institute:

The Committee on Meetings has arranged the program of the stated meetings of the Institute as heretofore. It is the intention of the Committee to continue to make the monthly meetings specially interesting for the membership at large and for the general public.

A number of new inventions were shown during the past nine months, and several articles of permanent value were secured for the Institute JOURNAL.

The small attendance at these meetings is still the rule, and it is undoubtedly due, in a great measure, to the location of the Institute building.

Respectfully submitted,

WASHINGTON JONES,
Chairman.

PHILADELPHIA, PA., January 13, 1909.

REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS FOR THE YEAR 1908.

To the President and Members of the Franklin Institute:

The Committee on Science and the Arts has the honor to submit the following account of its operations during the nine months, ending September 30, 1908. The total number of cases on the Record-book on September 30, 1908, was 71, of which 45 were carried over from previous years; 26 were new cases added during the year; the number of cases disposed of during 1908 was 12; the number of cases pending on September 30, 1908, was 59. In 4 cases the Elliott Cresson Medal was awarded; 3 received the award of the John Scott Legacy Medal and Premium; 1 received the Edward Longstreth Medal of Merit, and 1 received the Certificate of Merit. Two reports were made advisory and 1 application was dismissed. There were 3 protested cases, which have been included among those pending. The list of awards is appended hereto.

A Sub-Committee on Reorganization was appointed early in the year to recommend methods to increase the efficiency of the Committee's work.

This Sub-Committee has not yet filed its final report, but it has reported progress, to the effect that it has held frequent meetings during the year, has practically completed its work, and will soon report recommending methods, and amendments to the By-laws of the Institute, and to the Regulations of the Committee, to put them into effect, which in the opinion of the Sub-Committee will, if adopted, increase the efficiency and raise the standard of the work of the Committee.

While, therefore, the full report and result of the labors of this Sub-Committee cannot be included in this report, yet its work must be considered an important part of the activities of the Committee for the year, placing it harmoniously in line with the efforts being made under the leadership of the present able President to improve the work of the Institute as a whole, and make it continue worthy the high position it has always held.

Respectfully submitted,

JAS. S. ROGERS,
Chairman.

PHILADELPHIA, PA., January 6, 1909.

APPENDIX.

DETAILS OF THE COMMITTEE'S WORK DURING THE NINE MONTHS ENDING SEPTEMBER 30, 1908.

Number of cases pending on December 31, 1907	45	
Number of cases proposed January 1–September 30, 1908	26	
Total number of cases before the Committee at time of report,		71
Total number of cases finally disposed of to September 30, 1908,	12	
Total number of cases pending September 30, 1908	59	
		71

The 12 cases disposed of were determined as follows:

Award of the Elliott Cresson Medal	4
Award of the John Scott Legacy Medal and Premium	3
Award of the Edward Longstreth Medal of Merit	1
Award of the Certificate of Merit	1
Reports made advisory	2
Applications dismissed	1
Total	12

DETAILS OF AWARDS, ETC.

AWARDS OF THE ELLIOTT CRESSON MEDAL.

2397. Henry A. Wise Wood, for his "Autoplate Machine."
2416. Anatole Mallet, for his "Articulated Compound Locomotive."
2424. Romeyn B. Hough, for his "Contributions and Characteristics and Uses of American Woods."
2427. Patrick B. Delany, for his "Telepost—New System of Automatic Telegraphy."

AWARDS OF THE JOHN SCOTT LEGACY PREMIUM AND MEDAL.

2395. Mathias Pfatischer, for his "Variable Speed Motor."
2417. William I. Ballentine, for his "Process of Testing the Hardness and Density of Metals and other Materials."
2422. Homer A. Herr, for his "Improvement in Presses for the Extraction of Liquids."

AWARDS OF THE EDWARD LONGSTRETH MEDAL.

2425. Dr. Allerton S. Cushman, for his "Researches on the Corrosion of Iron and Steel."

AWARDS OF THE CERTIFICATE OF MERIT.

2369. General Electric Company, for their "Magnetite Lamp."

REPORTS MADE ADVISORY.

2410,
2418.

APPLICATION DISMISSED.

2414.

FRANKLIN INSTITUTE

PROBLEMS IN THE STRENGTH OF MATERIALS SOLVED BY ELEMENTARY MATHEMATICS IN THE NIGHT-COURSES OF THE INSTITUTE.

BY

LUCIEN E. PICOLET,
Director, School of Machine Design.

MODERN text-books on the strength of materials planned to meet the requirements of technical schools, nearly uniformly adhere to a method of treatment in which the higher mathematics taught in an undergraduate course is, very properly, employed to the exclusion of other methods. Probably, for that reason, it is generally assumed that a knowledge of the higher mathematics is indispensable to the satisfactory study of the subject.

There is a large class who are called upon to deal with the relatively more simple problems in structural design, who have not the opportunity of securing the necessary mathematical preparation for a study of the best available text-books. This class the Institute aims to aid by its night-courses in machine design.

Courses in algebra, geometry, and plane trigonometry are provided and with this preparation it has been found possible to solve many of the problems in mechanics and the strength of materials usually treated by the methods of the differential calculus.

Most of these problems belong to the classes involving investigation for maximum and minimum and the process of integration.

The substitutes employed are known and tried devices and, within their scope, appear to have been utilized for comparatively few special cases. How extensively the ground can be covered may be judged from the sequel.

MAXIMA AND MINIMA.

When the relation between two variable quantities, a and x, is expressible in the form of the quadratic

$$ax^2+bx+c=0,$$

the condition for maximum or minimum is that the quantity under the radical in the solution for x,

$$x=\frac{-b\pm\sqrt{b^2-4ac}}{2a},$$

shall be zero.

The greatest possible value of a is that which makes $4\ ac=b^2$. For any greater value the expression becomes imaginary and inadmissible when real values only are considered.

The minimum occurs when $4\ ac$ consists of two or more terms and decreasing the one sought increases the value of $4\ ac$.

Both maximum and minimum occur when $b^2-4ac=0$ forms a quadratic in terms of the variable.

The various phases and limitations of the method are fully treated in Williamson's Differential Calculus.

INTEGRATION.

The simple integrals of the form

$$\int dx, \quad \int xdx, \quad \int x^2dx \quad \text{and} \quad \int x^3dx$$

cover the solution of nearly all the formulas given in the several hand-books issued by structural steel manufacturers. These can be readily evaluated by a purely algebraic method in a manner perfectly intelligible to students conversant with the elements of algebra or by a geometric method which has been in considerable use for the elementary treatment of special cases.*

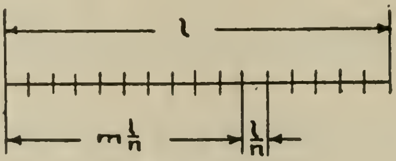

Fig. 1.

Fig. 1 is a graphic representation of the summation of these integrals between the limits of l and o.

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* Strength of Materials—De Volsen Wood. Mechanics Applied to Engineering—Goodman.

The length l is divided into n equal parts which may be indefinitely diminished by indefinitely increasing the value of n. The quantity

$$\frac{l}{n} \text{ corresponds to } \triangle x$$

and

$$m\frac{l}{n} \text{ corresponds to the variable } x.$$

The simple integral

$$\int_o^l dx$$

may be expressed by

$$\sum_o^l \frac{l}{n} \quad \text{or} \quad \frac{l}{n}$$

taken n times which equals l regardless of the magnitude of n. a result evident enough from inspection.

The evaluation of the remaining expressions is not so evident and requires demonstration.

The expression

$$\int_o^l xdx$$

may be written by the notation of Fig. 1

$$\sum_o^l \left(m\frac{l}{n}\right)\frac{l}{n}$$

when m is successively 1, 2 3 . . . n to n terms. The sum of these products is accordingly

$$\sum_o^l \left(m\frac{l}{n}\right)\frac{l}{n} = \left(\frac{l}{n}\right)\frac{l}{n} + \left(2\frac{l}{n}\right)\frac{l}{n} + \left(3\frac{l}{n}\right)\frac{l}{n} + \ldots\ldots + \left(n\frac{l}{n}\right)\frac{l}{n}$$

This reduces at once to the simple arithmetic series,

$$\sum_o^l \left(m\frac{l}{n}\right)\frac{l}{n} = \frac{l^2}{n^2}[1+2+3+4+\ \ldots\ldots\ n]$$

The sum of an arithmetic series is

$$S_1 = \frac{n}{2}[2a+(n-1)d]$$

and when $a = 1$ and $d = 1$

$$S_1 = \frac{n(n+1)}{2}$$

the sum of n terms of the series in brackets. Inserting this value of the sum for the series,

$$\sum_o^l \left(m\frac{l}{n}\right)\frac{l}{n} = \frac{l^2}{n^2}\frac{n(n-1)}{2} = \frac{l^2}{2}$$

as n increases without limit.

In evaluating

$$\int_o^l x^2 dx$$

a similar treatment leads to the series,

$$\sum_o^l \left(m\frac{l}{n}\right)^2 \frac{l}{n} = \frac{l^3}{n^3}[1^2 + 2^2 + 3^2 + \ldots\ldots + n^2]$$

To find an expression for the sum of this series the following artifice * may be employed to express it in terms of an arithmetic series,

$$\begin{aligned}
n^3 - (n-1)^3 &= 3n^2 - 3n + 1 \\
(n-1)^3 - (n-2)^3 &= 3(n-1)^2 - 3(n-1) + 1 \\
(n-2)^3 - (n-3)^3 &= 3(n-2)^2 - 3(n-2) + 1 \\
\ldots\ldots \quad \ldots\ldots & \ldots\ldots\ldots\ldots\ldots\ldots \\
\ldots\ldots \quad \ldots\ldots & \ldots\ldots\ldots\ldots\ldots\ldots \\
(3)^3 - (2)^3 &= 3(3)^2 - 3(3) + 1 \\
(2)^3 - (1)^3 &= 3(2)^2 - 3(2) + 1 \\
(1)^3 - (0)^3 &= 3(1)^2 - 3(1) + 1
\end{aligned}$$

Adding the corresponding members, all but the first term of the left member of the first equation cancel. The sum of the first terms of the right members, S_2, is the sum of the series required, taken 3 times; the sum of the second terms is

$$3S_1 = 3\frac{n(n-1)}{2}$$

and the sum of the last terms is n and

$$n^3 = 3S_2 - 3\frac{n}{2}(n+1) + n$$

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* Hall and Knight's Higher Algebra.

Solving for S_2

$$S_2 = \frac{n(n+1)(2n+1)}{6}$$

and

$$\sum_o^l \left(m\frac{l}{n}\right)^2 \frac{l}{n} = \frac{l^3}{n^3}\,\frac{n(n+1)(2n+1)}{6}$$

As n is indefinitely increased

$$\sum_o^l \left(m\frac{l}{n}\right)^2 \frac{l}{n} = \frac{l^3}{n^3}\,\frac{n^3}{3} = \frac{l^3}{3}$$

The integral

$$\int_o^l x^3 dx$$

yields to a similar treatment

$$\sum_o^l \left(m\frac{l}{n}\right)^3 \frac{l}{n} = \frac{l^4}{n^4}[1^3 + 2^3 + 3^3 + \ldots\ldots + n^3]$$

$$\begin{aligned}
n^4 - (n-1)^4 &= 4n^3 - 6n^2 + 4n - 1\\
(n-1)^4 - (n-2)^4 &= 4(n-1)^3 - 6(n-1)^2 + 4(n-1) - 1\\
(n-2)^4 - (n-3)^4 &= 4(n-2)^3 - 6(n-2)^2 + 4(n-2) - 1\\
\ldots\ldots\ldots &\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\\
\ldots\ldots\ldots &\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\\
(3)^4 - (2)^4 &= 4(3)^3 - 6(3)^2 + 4(3) - 1\\
(2)^4 - (1)^4 &= 4(2)^3 - 6(2)^2 + 4(2) - 1\\
(1)^4 - (0)^4 &= 4(1)^3 - 6(1)^2 + 4(1) - 1
\end{aligned}$$

Adding as in the previous case

$$n^4 = 4S_3 - 6S_2 + 4S_1 - n$$

$$4S_3 = n^4 + n + n\,(n+1)\,(2n+1) - 2n\,(n+1)$$

and, finally,

$$S_3 = \left[\frac{n\,(n+1)}{2}\right]^2$$

Accordingly the value of the integral as n approaches infinity, is

$$\sum_o^l \left(m\frac{l}{n}\right)^3 \frac{l}{n} = \frac{l^4}{n^4}\,\frac{n^4}{4} = \frac{l^4}{4}$$

The foregoing methods necessarily appear clumsy when it is considered that a general formula for a positive integral exponent can be algebraically derived.* This general formula, however, requires a more extensive knowledge of algebraic series than is available from the course of study premised.

PROBLEMS IN MAXIMA AND MINIMA.

Plane of Rupture by Shear from Compression.—The angle of the plane of failure by shear in a short prismatic specimen subjected to compression is easily determined by the method of algebraic maximum.

Let A be the uniform cross-sectional area of the prism, Fig. 2, p, the compression force, S the shearing force along the plane

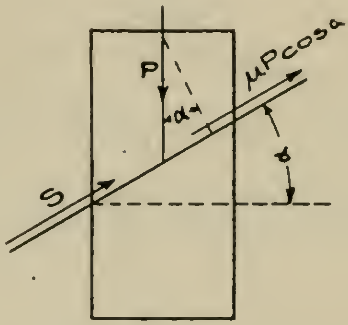

Fig. 2.

of failure—making the angle α with the normal plane, S_s, the unit shear, S_c the unit compression and μ, the coefficient of friction. Failure occurs along a plane at the angle a which makes the value of S_s a maximum when

$$S_c > S_s$$

From Fig. 2 the relationship of S_s, S_c and α is

$$S_c \tan a = S_s(1 + \tan^2 a) + \mu S_c$$

and writing x for $\tan a$

$$S_s x^2 - S_c x + S_s + \mu S_c = 0$$

from which

$$x = \frac{S_c \pm \sqrt{S_c^2 - 4S_s(S_s + \mu S_c)}}{2S_s}$$

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* Treatise on Algebra—C. Smith.

The value of x for a maximum is

$$x=\frac{S_c}{2S}$$

where S_c and S_s are related by the equation

$$S_c^2-4S_s(S_s+\mu S_c)=0$$

Combining these two equations

$$x^2-2\mu x-1=0$$

and

$$\tan^2 a-2\tan\varphi\tan a-1=0$$

where

$$\mu=\tan\varphi$$

This reduces to

$$\frac{2\tan a}{1-\tan^2 a}=-\cot\varphi$$

or

$$\tan 2a=-\tan(90-\varphi)=\tan(90+\varphi)$$

and the value of a for maximum unit shear is

$$a=45°+\frac{\varphi}{2}$$

The formula for maximum resultant tension in a rectangular prism subjected to both tension and shear is of frequent application in the design of machine details. Though more complex than the preceding it can be derived by the same method.

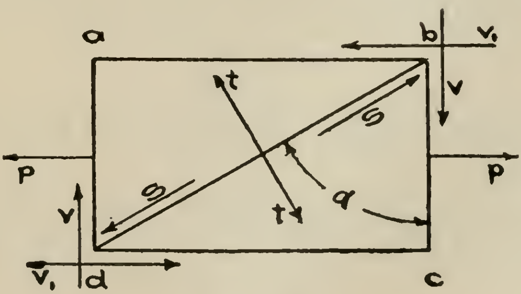

Fig. 3.

Unit tensile forces p are applied to the opposite faces $a\ d$ and $b\ c$ of the prism $a\ b\ c\ d$, Fig. 3.

The shearing unit stress v on the same faces are equilibrated by the equal unit shears v_1 on the faces $a\,b$ and $d\,c$.

These forces produce resultant unit tensions t and resultant unit shears S along the diagonal $b\,d$ making the angle α with the normal to p.

Resolving the forces in the direction of t, normal to $b\,d$

$$t\,bd = v\,ab\cos a + v\,bc\sin a + p\,bc\cos a$$

Dividing by bd

$$t = 2v\sin a\cos a + p\cos^2 a$$

or

$$t = v\sin 2a + \frac{p}{2}(\cos 2a + 1)$$

Resolving the forces along bd

$$S\,bd = v\,ab\sin a - v\,bc\cos a + p\,bc\sin a$$

and

$$S = v(\sin^2 a - \cos^2 a) + p\cos a\sin a$$

which may be written

$$S = \frac{p}{2}\sin 2a + v\cos 2a$$

Writing x for $\cos 2a$

$$t = v\sqrt{1-x^2} + \frac{p}{2}(x+1)$$

Transposing and squaring

$$v^2(1-x^2) = t^2 - pt(x+1) + \frac{p^2}{4}(x+1)^2$$

or

$$\left(\frac{p^2}{4} + v^2\right)x^2 + \left(\frac{p^2}{2} - pt\right)x + \frac{p^2}{4} - pt + t^2 - v^2 = 0$$

Solving for x

$$x = \frac{pt - \frac{p^2}{2} \pm \sqrt{\left(\frac{p^2}{2} - pt\right)^2 - 4\left(\frac{p^2}{4} + v^2\right)\left(\frac{p^2}{4} - pt + t^2 - v^2\right)}}{2\left(\frac{p^2}{4} + v^2\right)}$$

Making the quantity under the radical zero

$$-v^2t^2 + pv^2t + v^4 = 0$$

and

$$t=\frac{-pv^2\pm\sqrt{p^2v^4+4v^6}}{-2v^2}$$

which reduces to

$$t=\frac{p}{2}\pm\sqrt{\frac{p^2}{4}+v^2}$$

In a like manner it may be shown that the maximum resultant unit shear is

$$S=\sqrt{\frac{p^2}{4}+v^2}$$

Maximum Bending Moment for Beams.—The algebraic expression for moments on beams subjected to varying loads is generally of higher degree than the second and recourse must be had to the property that the area of the diagram for vertical shear is equivalent to the bending moment. This may be shown graphically from the shear diagram.

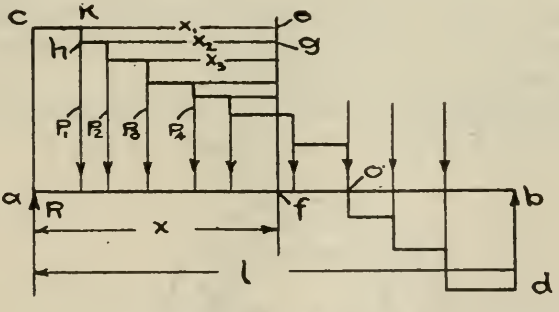

Fig. 4.

The stepped line $c\ o\ d$, Fig 4, represents the shear diagram of a beam loaded in any manner either by concentrated loads p_1, p_2, p_3, &c., or a continuously varying load which may also be represented by separate concentrated loads taken close together.

The bending moment at a distance x from the left end, where R is the reaction, is

$$M=Rx-p_1x_1-p_2x_2-p_3x_3+\&c.$$

The term Rx is represented by the area of the rectangle $a\ c\ c\ f$ whose altitude is R and base x. Each product Px

diminishes the area Rx by a rectangle $k\ e\ g\ h$ forming a series of steps. The height of the steps is successively p_1, p_2, p_3, &c., and the height R at each point of application of load is diminished a like amount. That is the altitude of the diagram at any point is

$$R - \Sigma p$$

which represents the vertical shear.

It follows that the area of the vertical shear diagram for concentrated loads is equivalent to the bending moment. The same reasoning applies to continuous loads in which case the loads are small and separated by a minute interval. The steps then disappear and become a continuous slope.

At some point *o*, the area of the diagram ceases to increase for any increase of distance from *a* and at that point the area or the bending moment becomes a maximum.

DEFLECTION OF BEAMS.

In investigating the deflection of beams, the relation between the bending moment and radius of curvature may be readily demonstrated by the simple and lucid method given in Unwin's Machine Design.

Assume the beam to be very long and bent to the form of a complete circle of radius ρ at the neutral axis Fig. 5.

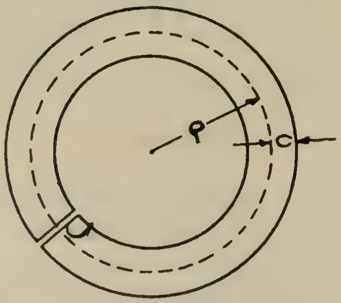

Fig. 5.

Let M be the bending moment, S, the unit stress at the most remote fibre, and c the distance of the most remote fibre from the neutral axis.

The length of the most remote fibre is $2\pi(\rho+c)$. The length of the neutral axis is $2\pi\rho$ and the extension due to bending is $2\pi c$. The extension per unit of length is consequently $\frac{c}{\rho}$ and

$$S=\frac{c}{\rho}E$$

where E is the coefficient of elasticity, and finally replacing S by $\frac{Mc}{I}$ where I is the moment of inertia

$$\rho=\frac{EI}{M}\cdot$$

GENERAL FORMULA FOR DEFLECTION.

A cantilever beam offers the simplest case of beam deflection. The beam is held horizontally at the point a Fig. 6, its initial position being $a\ b$. Under the action of the loads it deflects at the end a distance D.

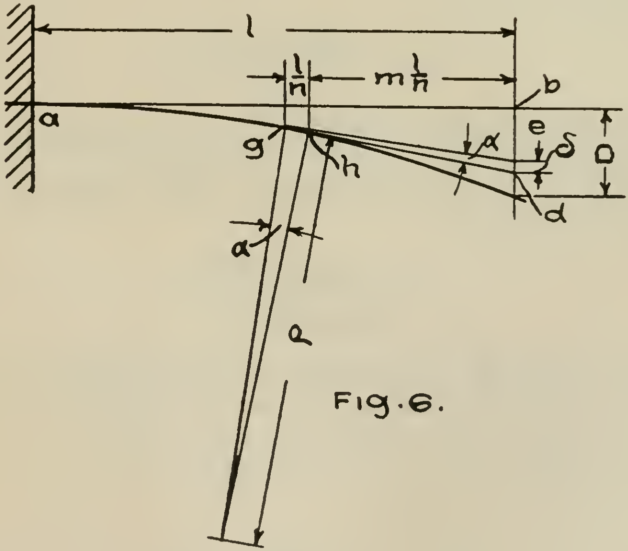

Fig. 6.

Suppose it to be divided into a large number of small parts, each $\frac{l}{n}$ long. At a distance from the end $m\frac{l}{n}$, the bending moment is M and the radius of curvature is ρ.

If the load were removed from the part $m\frac{l}{n}$ the axis would take the position $h\ d$ tangent to the elastic curve at h, and if, in addition, the load upon the small length $\frac{l}{n}$ were removed the axis would take the position $g\ e$ tangent at g.

It, at once, follows from the figure that the relation between the radius of curvature at $\frac{l}{n}$ and the deflection δ produced at the end of the beam is, by combining

$$\delta=\left(m\frac{l}{n}\right)a \quad \text{and} \quad \rho a=\frac{l}{n}$$

$$\delta=\frac{\left(m\frac{l}{n}\right)\frac{l}{n}}{\rho}$$

Inserting the value of ρ

$$\delta=\frac{M\left(m\frac{l}{n}\right)\frac{l}{n}}{EI}$$

and the total deflection is the sum of the deflections due to the curvature of all the small lengths $\frac{l}{n}$ taken along the entire length of the beam or

$$D=\sum_{o}^{l}\frac{M\left(m\frac{l}{n}\right)\frac{l}{n}}{EI} \qquad (1)$$

This formula is true not only for cantilever beams but for all forms where l is the length between the end and the point where a tangent to the elastic curve is horizontal.

The value of the angle of the tangent at the end and the initial position of the beam is

$$\theta=\sum_{o}^{l}\frac{M\frac{l}{n}}{EI} \qquad (2)$$

Formula (1) may be recognized as the *statical moment* of the bending moment diagram divided by EI, and (2) the *area* of the bending moment diagram divided by EI. These for subsequent reference will be expressed in the customary notation

$$D = \sum_{o}^{l} \frac{Mx\,dx}{EI} \tag{3}$$

$$\theta = \sum_{o}^{l} \frac{M\,dx}{EI} \tag{4}$$

In a simple beam uniformly loaded with a load ω per unit of length, the tangent to the elastic curve is horizontal at the centre and the limits of integration are $\frac{l}{2}$ and o. The bending moment

$$M = \frac{\omega\,lx}{2} - \frac{\omega\,x^2}{2}$$

Then by (3)

$$D = \frac{1}{EI}\sum_{o}^{\frac{l}{2}}\left(\frac{\omega\,lx^2}{2} - \frac{\omega\,x^3}{2}\right)dx$$

$$D = \frac{1}{EI}\left(\frac{\omega l^4}{48} - \frac{\omega l^4}{128}\right) = \frac{5}{384}\,\frac{\omega l^4}{EI}$$

When a beam is of the "built-up" type and of variable section, formula (3) may be applied graphically by plotting as in Fig. 7 values of $\frac{M}{I}$ for various points along the beam and dividing the area of the diagram so formed to the point of maximum deflection, when the tangent to the elastic curve is horizontal, by E.

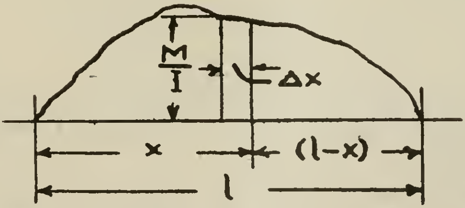

Fig. 7.

When the loading is irregular, the point of maximum deflection is not at the centre and the limits of summation must be determined. This may be done by the application of formula (4).

The beam represented in Fig. 8 has its maximum deflection at the unknown distance x from a. The tangent at the point b makes the angle θ with the horizontal ab, and its value may be found from (3)

$$\theta = \frac{D_1}{l} = \frac{1}{l} \sum_o^l \frac{Mx \Delta x}{EI}$$

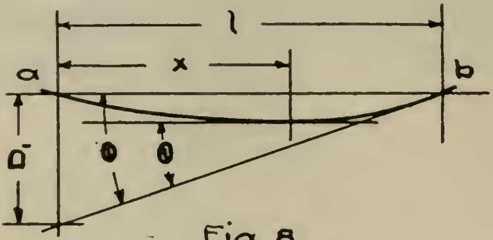

Fig. 8.

that is, the area of the statical moment diagram. This line makes the same angle with a tangent at the point x, and another value of θ from (4) is,

$$\theta = \sum_x^l \frac{M \Delta x}{EI}$$

by finding a distance $l - x$ subtending an area, from the moment diagram in Fig. 7, equivalent to the value of θ previously found.

The condition determining x is, therefore,

$$\theta = \frac{1}{l} \sum_o^l \frac{Mx \Delta x}{EI} = \sum_x^l \frac{M \Delta x}{EI} \qquad (5)$$

The application of this relationship may be illustrated by a simple example.

The beam of length l in Fig. 9 carries a concentrated load p at a distance $\frac{1}{4} l$ from the left end. The bending moment diagram is composed of two right triangles $a\ c\ d$ and $b\ c\ d$ with a common altitude $\frac{3}{16}\ pl$.

The statical moment of $a\ c\ b$ about a is

$$\frac{5}{128} pl^3$$

and

$$\frac{1}{l} \sum_o^l \frac{Mx \Delta x}{EI} = \frac{1}{EI} \frac{5}{128} pl^2$$

The area of the diagram between the limits of l and x,

$$\sum_{x}^{l} \frac{M x \llcorner x}{EI}$$

is

$$\frac{1}{EI} \frac{p}{8} (l-x)^2$$

By (5)

$$\frac{p}{8} (l-x)^2 = \frac{1}{l} \left(\frac{5}{128} p l^3 \right)$$

and

$$l - x = .559\, l.$$

If the area of the triangle $b\ c\ d$ were less than $\frac{5}{128}\, pl^2$, the distance x would fall on the left of the apex c and the algebraic expression would be simplified by integrating from the right end b.

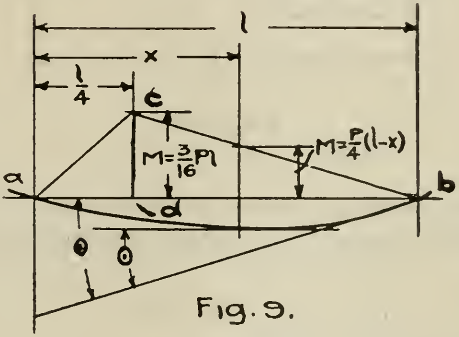

Fig. 9.

The maximum deflection is, then, by (3)

$$D = \sum_{0.441\, l}^{l} \frac{M x \llcorner x}{EI}$$

or

$$D = 0.0246 \frac{p l^3}{EI}$$

RESTRAINED BEAMS.

In the usual cases of symmetrical loading of restrained beams the end moments are equal. With unsymmetrical loading the end restraints are unequal and at any point distant x the moment may be expressed in terms of the moments at the ends.

The beam in Fig. 10 is acted upon at the ends by unequal and opposite moments *Ma* and *Mb*. These are held in equilibrium by the forces *p* at the supports constituting a couple *pl* equivalent to *Ma*—*Mb*. The force *p* acting on the side of the greater moment tends to diminish the reaction due to the superimposed load by the force

$$p=\frac{Ma-Mb}{l} \tag{6}$$

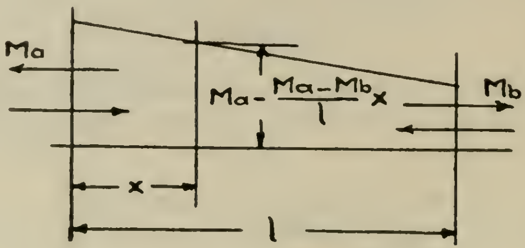

Fig. 10

If *m* is the bending moment at the distance *x* from the left end due to these loads, the resultant bending moment is

$$M=m-Ma+\frac{Ma-Mb}{l}x \tag{7}$$

When a restrained beam is uniformly loaded

$$Ma=Mb,\quad M=m-Ma,\quad \text{and}\quad m=\frac{\omega l}{2}-\frac{\omega x^2}{2}$$

Applying (3)

$$\theta=\frac{1}{E}\sum_{o}^{l}\left(\frac{\omega l}{2}x-\frac{\omega x^2}{2}-Ma\right)dx=0$$

and

$$\frac{\omega l^3}{4}-\frac{\omega l^3}{6}-Mal=0$$

from which

$$Ma=\frac{\omega l^2}{12}$$

At a distance x from the left end

$$M = \frac{\omega l}{2}x - \frac{\omega x^2}{2} - \frac{\omega l^2}{12}$$

When

$$x = \frac{l}{2} \quad M = \frac{\omega l^2}{8} - \frac{\omega l^2}{12} = \frac{\omega l^2}{24}$$

Making $M = o$, the points of inflection are

$$x = \frac{l}{2} \pm \sqrt{\frac{1}{12}}$$

The deflection at the centre is

$$D = \frac{5}{384}\,\frac{\omega l^4}{EI} - \frac{1}{EI}\sum_{o}^{\frac{l}{2}} Maxdx$$

$$D = \frac{5}{384}\,\frac{\omega l^4}{EI} - \frac{1}{8}Mal^2$$

$$D = \frac{5}{384}\,\frac{\omega l^4}{EI} - \frac{\omega l^4}{96} = \frac{1}{384}\,\frac{\omega l^4}{EI}$$

Theorem of Three Moments.—The moments at the points of support in the same plane of any two consecutive spans l_1 and l_2 of a continuous beam, Fig. 11, are A, B and C.

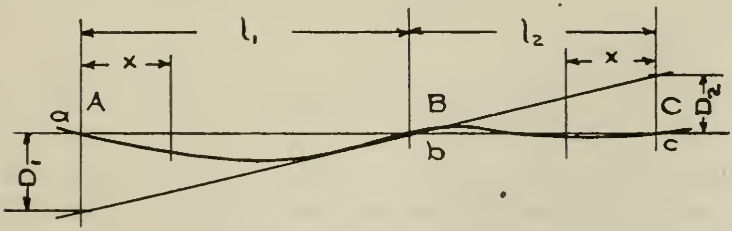

Fig. 11.

A tangent to the elastic curve at the middle support b intercepts lengths D_1 and D_2 on perpendiculars at the ends a and c.

Reckoning from the left support, a,

$$D_1 = \frac{1}{EI}\sum_{o}^{l_1}\left(m_1 - A + \frac{A-B}{l}x\right)xdx$$

In the same manner reckoning from the right support, *c*,

$$D_2 = \frac{1}{EI} \sum_o^{l_2} \left(m_2 - C + \frac{C-B}{l} x \right) x dx$$

when m_1 and m_2 are the moments of the superimposed loads.

From the figure

$$\frac{D_1}{l_1} = -\frac{D_2}{l_2}$$

and

$$\frac{1}{l_1} \sum_o^{l_1} \left(m_1 - A + \frac{A-B}{l} x \right) x dx = -\frac{1}{l_2} \sum_o^{l_2} \left(m_2 - C + \frac{C-B}{l} x \right) x dx$$

which may be written

$$\frac{1}{l_1} \left[\sum_o^{l_1} m_1 x dx - \sum_o^{l_1} A x dx + \sum_o^{l_1} \frac{A-B}{l} x^2 dx \right] =$$

$$-\frac{1}{l_2} \left[\sum_o^{l_2} m_2 x dx - \sum_o^{l_2} C x dx + \sum_o^{l_2} \frac{C-B}{l} x^2 dx \right]$$

Writing μ_1 and μ_2 for the terms

$$\Sigma m x dx$$

and integrating the others,

$$\frac{\mu_1}{l_1} - \frac{A l_1}{2} + \frac{A-B}{3} l_1 = -\frac{\mu_2}{l_2} + \frac{C l_2}{2} - \frac{C-B}{3} l_2$$

This reduces to

$$6 \left(\frac{\mu_1}{l_1} + \frac{\mu_2}{l_2} \right) = A l_1 + 2B (l_1 + l_2) + C l_2$$

which expresses the relation between the unknown moments at the points of support and the quantities μ_1 and μ_2 in terms of the known loads.

If a continuous beam of two equal spans with free ends bears a uniform load ω per unit of length

$$l_1 = l_2, \; \mu_1 = \mu_2 = \sum_o^{l_1} m_1 x dx = \sum_o^{l} \left(\frac{\omega l}{2} x - \frac{\omega x^2}{2} \right) x dx = \frac{\omega l^4}{24}$$

and (8) becomes

$$A + 4B + C - \frac{\omega l^2}{2} = 0$$

In a beam of three supports $A = C = 0$ and

$$B = \frac{\omega l^2}{8}$$

The end reactions are, from (6)

$$\frac{\omega l_1}{2} - \frac{\omega l}{8} = \frac{3}{8}\omega l$$

When the beam has four supports, the end moments A and D are zero and $B = C$, then

$$5B = \frac{\omega l^2}{2} \quad \text{and} \quad B = \frac{\omega l^2}{10}$$

The end reactions are

$$\frac{\omega l}{2} - \frac{\omega l}{10} = \frac{4}{10}\omega l$$

The formulas on deflection for simple and restrained beams and continuous beams as well are of a form more convenient for graphic application to irregular loading and variable section than those available in the text-books in general use.

The geometric method of derivation is probably applicable only when the bending moment is a function of x. When the moment is a function of y or both x and y, as in the investigation of the elastic equilibrium of columns, this method yields an unwieldy expression not at all comparable in ease of reduction with the differential equation usually employed.

The few representative problems discussed are presented to demonstrate that many of the beam problems usually accepted without proof in an elementary course may be satisfactorily solved by elementary methods. In some cases the solutions are found with less labor than by the usual methods, but, in its present state of development, it is not as broadly applicable to the general treatment of the subject.

It is a temporary expedient to be supplanted, it is hoped in the near future, by the organization of courses in technical and allied mathematical subjects of a grade in keeping with the standing of the Institute.

BOOK NOTICES

PENROSE'S PICTORIAL ANNUAL. A Review of the Graphic Arts, vol. xiv, 1908–9. The Process Year Book, edited by Wm. Gamble. London, A. W. Penrose & Co., Ltd., 1909, for sale in New York by Tennant & Ward.

The 14th volume of this well-known Annual has just come from the press. It contains the usual amount of interesting and valuable information for the process worker and the tricolor printer. Many illustrations are included which serve as specimens of the numerous processes which the book describes. R.

DIE ENGLISCHEN ELEKTROCHEMISCHEN PATENTE. Auszuege aus den Patentschriften, zusammengestellt und mit ausfuehrlichem Sach-und Namenregister versehen von Dr. P. Ferchland, Patentanwalt in Berlin. Erster Band: Elektrolyse. Mit vielen Figuren im Text. Halle a S. Verlag von Wilhelm Knapp 1907. Paper, price 9 marks.

The 29th volume of the Monographien ueber angewandte Elektrochemie is a review of the English patents on Electro Chemistry. It corresponds in arrangement with the same author's volume of German Electro Chemical Patents issued some time ago. The earliest patent contained in the present volume is dated 1842 and the abstracts are brought down to the end of 1906. The work will be in several volumes of which this is the first. As a reference book it will be extremely useful. R.

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Pennsylvania Department of Agriculture. The Zoological Bulletin of the Division of Zoology. September 1, October 1, November 2, December 1, 1908. 4 pamphlets, illustrations, 8vo. Harrisburg, State printer, 1908.

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ELECTRICAL SECTION

(*Stated meeting held Thursday, January 21, 1909*)

THE AUTOMATIC SYSTEM OF TELEPHONY.

(*Stated meeting held Wednesday, January 20, 1909.*)

BY
W. LEE CAMPBELL,
General Superintendent, Automatic Electric Company, Chicago, Ill.

As soon as Prof. Bell had demonstrated, by his exhibit at the Centennial Exposition at Philadelphia, Pa., in 1876, that it was possible for two persons to talk with each other over a completed electrical circuit, inventors began to devise methods for connecting one telephone with another. As it was manifestly impossible for individual lines to extend from one telephone to every other telephone, it became evident that the lines from each telephone must terminate centrally in a common group or number of groups in order that connections could be conveniently made either by some mechanical agent or by a manual operator. While the possibility of making these connections mechanically was almost immediately suggested, naturally the first method that appealed to inventors as affording the readiest solution of the problem was that of manual operation. Hence arose the manual switchboard supervised by operators who, in response to the request of the subscriber, selected the particular line wanted and

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[NOTE.—The Franklin Institute is not responsible for the statements and opinions advanced by contributors to the Journal.]

connected the line of the calling subscriber with it by hand. This method made telephony commercially possible and supplied a more or less satisfactory service. While manual switchboards were being rapidly developed, a few daring inventors persisted in the endeavor to develop a machine which would enable the telephone subscriber to make his own connections and disconnections. This has resulted in what to-day is known as the automatic switchboard.

The earliest known workers along this line were M. Daniel Connolly of Philadelphia, Pa., Thos. A. Connolly of Washington, D. C., and Thos. J. McTighe of Pittsburg, Pa. These gentlemen working in unison applied for their first patent on September 10, 1879, and the patent was issued in December of the same year, only three years after Prof. Bell's public demonstrations. The apparatus, however, did not prove a success commercially. Undaunted other inventors continued experiments along the same line with almost heroic fortitude. In spite of hardships, financial losses, and ridicule heaped upon them by the manufacturers of manual apparatus, efforts towards perfecting an automatic switchboard were persisted in for twenty-three years before substantial recognition was secured.

To-day there are several automatic switchboard systems on the market, but only one has attained commercial prominence.

Since the subject is a very large one, the discussion will be confined to this particular system, generally known as the Strowger. A. B. Strowger, after whom the system is named, was an undertaker in Kansas City, Mo. It is related that he was naturally very sensitive and retiring. In the conduct of his business it was frequently necessary for him to use the telephone, and he so often suffered from the mistakes, curt answers, interruptions, and delays of the operators that he determined to make a switchboard that needed no operators. He set to work, and the first tangible result was an application for a patent filed March 12, 1889. After many discouragements, Mr. Strowger, with the aid of his nephew, Mr. W. S. Strowger, and some mechanics, succeeded in 1890 in completing a working model. How crude this was may be surmised from the fact that it required five wires to operate the automatic switch from the telephone. Shortly after this the Strowgers were induced by Joseph Harris to move to Chicago, and in 1891 a company was incorporated, under the title Strowger Automatic Telephone Exchange, for the manufacture and promotion of the apparatus. Meanwhile changes and improvements were being made. The apparatus was exhibited in various cities over the country, in order to enlist capital and in order to secure a contract for a public exchange. These efforts were successful to an extent, and in 1892 the first public automatic telephone system was installed at La Porte, Ind., 13 years after Messrs. Connolly and McTighe applied for their patent. The fight was not yet won, however, and for ten years longer the existence of the "Strowger Automatic Telephone Exchange" was a constant struggle. Time and again the prospect of bankruptcy stared its officers in the face. A few small plants were installed and leased on a royalty basis, however, and by various means enough money was secured to keep going. The officers never lost faith, and, above all, the apparatus was constantly improved, refined, and its possibilities developed.

Interior Olive Street Exchange, San Francisco, Cal.

The Strowgers dropped out of the company after a few years, but the work was carried on under the direction of A. E.

Keith, who joined the company in 1892. Finally the apparatus won a very substantial recognition, a new company was formed, with Joseph Harris as Vice-President and General Manager and A. E. Keith as Chief Engineer and General Superintendent, and in 1902 one of the largest telephone factories in the country was equipped by them for the exclusive manufacture of automatic switchboards. In the six years that have intervened since then, automatic telephone switchboards have been installed in many of our large cities, and have given great satisfaction, both to the companies operating them and to the telephone users. Equipment of this type is to-day operating successfully in such large cities as Chicago, Ill., Los Angeles, Cal., Portland, Ore., Oakland, Cal., Omaha, Neb., Grand Rapids, Mich., Sioux City, Ia., Columbus, Ohio, Dayton, Ohio, Wilmington, Del., and in many smaller cities.

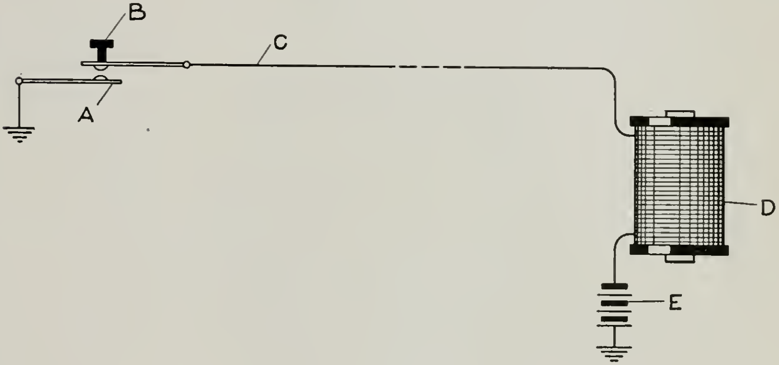
In the city of Los Angeles alone equipment is installed for serving 20,000 subscribers automatically. Apparatus is now being installed in San Francisco, Cal., for a new automatic system, which will commence to give service with equipment for 15,000 lines. This number is expected to be but the nucleus of a much larger system.

While an automatic switchboard is a very complicated-looking piece of apparatus, its functions are not difficult to understand. Every telephone in each of our large cities is connected to the central office by a " line " which consists of a pair of wires. For the purpose of conversation between any two subscribers it is necessary that the terminals of their lines should be connected together for the time. When conversation is completed, the two lines should be promptly disconnected.

In order to operate the mechanisms of the automatic switchboard to make and break these connections, it is necessary to send electrical impulses over the lines which extend from each telephone to the central exchange. As with the manual telephone, these lines consist only of the two required to complete the metallic electrical circuit necessary for successful and satisfactory conversation.

If we wish to send electrical impulses to an electro-magnet over a considerable distance, and these impulses are variable in number as determined by the operator, the simplest form of completing the circuit would be by means of a push-button. For instance, in Fig. 1, if *A* is a contact connected with a lead to ground at a telephone subscriber's station, *B* a push-button adapted to connecting the line *C* to the ground spring *A*, and if *D* is a coil at a central exchange connected to one side of a battery *E*, the other side of which is grounded, then on pressing the push-button a circuit is completed through the coil *D* over the line *C* and ground which takes the place of a second line. If the coil *D* can be energized in this way, it can be made to do work. This is perhaps the fundamental principle of automatic telephony in its simplest form. In order not to waste time and in order to avoid mistakes in counting on the part of the subscriber, the dial represented on the automatic wall telephone, Fig. 2, was designed. The appearance of the telephone, it will be seen, differs but little from that of the manual, the only difference being the addition of this dial or calling device to the exterior of the box. This dial is connected by a shaft to an impulse wheel on the inside of the telephone. If the subscriber desires to send five impulses, for instance, he does not press a push-button five times, but instead inserts a finger in the dial opposite the figure five and pulls the dial around to a stop adjusted to retain the finger at a certain point. The impulse wheel, being secured to the dial, turns with it. The dial is then released and, actuated by a clock-spring, returns to its original position. In doing so the impulse wheel closes contact between one side of the line and ground five times. This design is merely to facilitate the sending of impulses to the automatic switchboard, and is more satisfactory than operating a push-button.

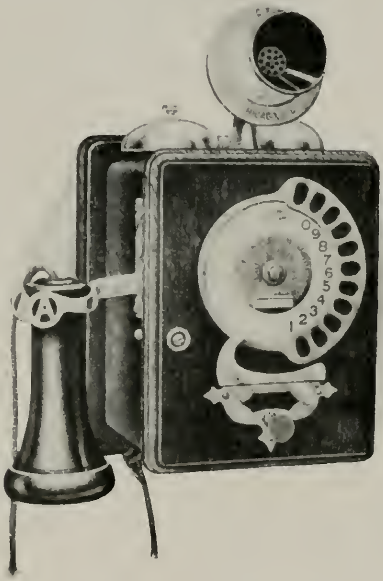
FIG. 1.



An automatic switchboard consists largely of machines operated by the subscriber by means of this dial to make and break connections between his own line and any other at will. In order to understand how these machines accomplish their work, let us begin with a system of ten subscribers only.

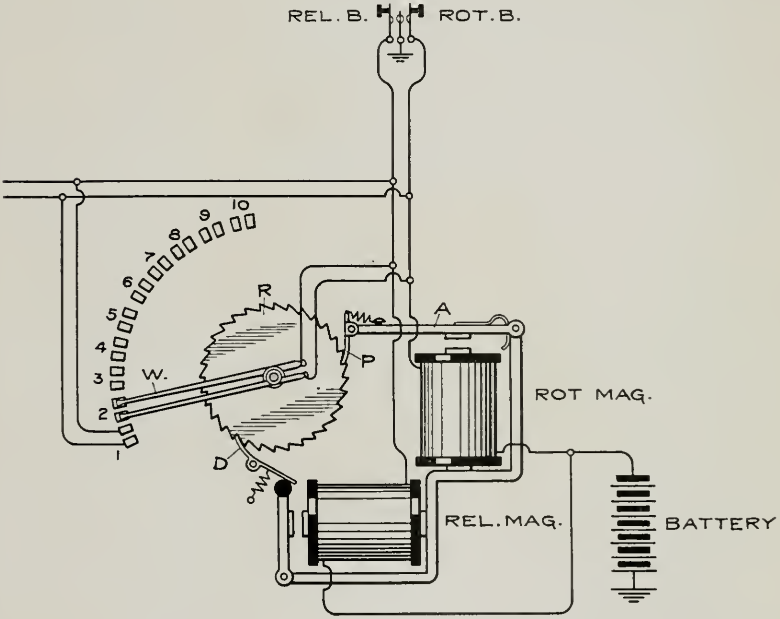
Fig. 3 illustrates ten subscribers' lines, terminating in ten pairs of metal plates or "bank contacts," arranged in the arc of a circle and numbered from 1 to 10. A ratchet-wheel *R,* is arranged with it centre at the centre subtended by this arc of contacts, and carries a pair of springs *W* technically called a wiper. The line of subscriber No. 1, by whom it is supposed that this machine is used, is represented as being connected not only to the first pair of bank contacts but also to the wiper *W*, to the rotary magnets, and to the release and rotary push-buttons.

FIG. 2.



Now suppose that subscriber No. 1 wishes to connect to line No. 2. He presses twice the rotary push-button located at his telephone. This closes a circuit twice from battery through the rotary magnet. Each time that this circuit is completed, the rotary magnet is energized and attracts its armature, *A*. This armature carries at the end of its arm the pawl *P,* which engages the ratchet-wheel *R* and moves it, and with it the wiper *W*, one step each time that the armature is attracted. Consequently, when *A* has been attracted and released two times, the wiper *W* will have been moved from its normal position at the left of the first pair of contacts and will rest upon pair No. 2 of bank contacts, thus bridging the gap between the terminals of line No. 1 and No. 2. By means not here shown subscriber No. 2 will be signalled and called to answer his telephone.

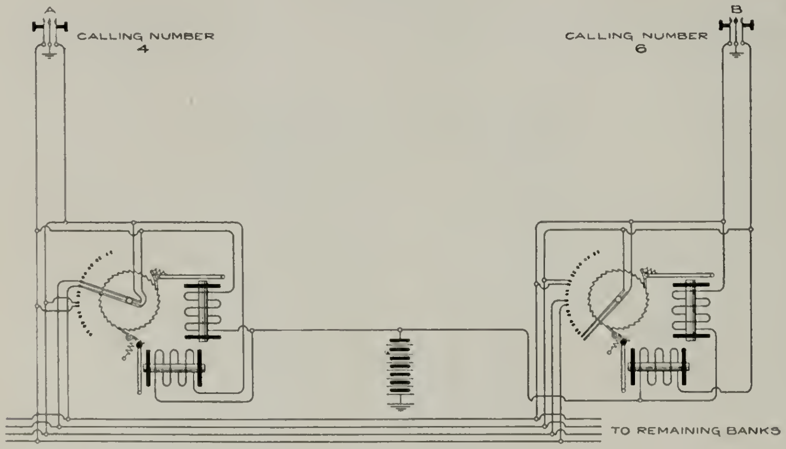
FIG. 3.



It is so arranged, that, when the conversation has been completed and the calling subscriber No. 1 hangs up his receiver, the release magnet will be momentarily energized and will attract its armature, thus pulling the retaining dog *D* out of engagement with the ratchet-wheel, which is then instantaneously returned to normal position by means of a clock-spring. This release is here represented as being effected by operating the push-button *Rel. B.* In a similar manner subscriber No. 1 could call any of the ten subscribers, or any of the other parties could by using his own machine call line No. 1.

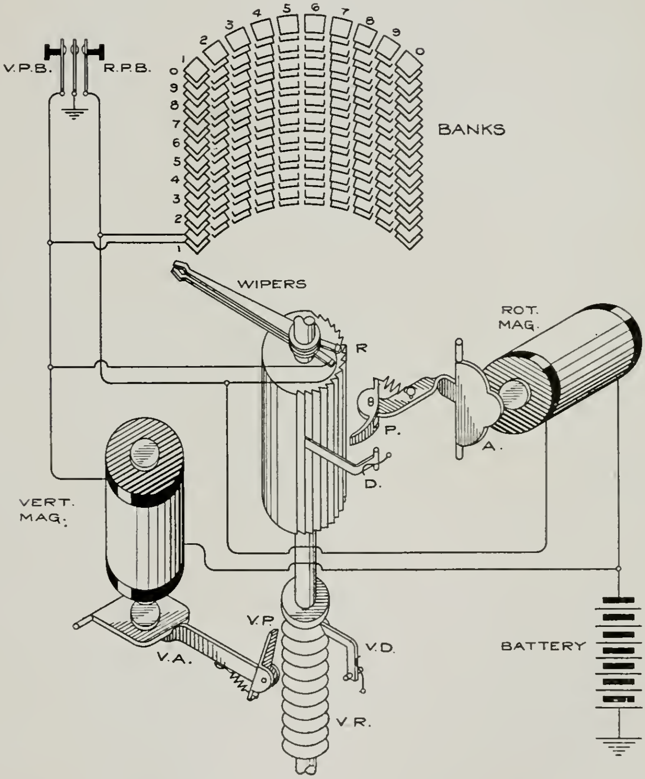
Each of the subscribers of this system of ten would possess one of these switching mechanisms with its groups of ten bank contacts. In order that each subscriber should be able to connect his line with that of every other line from his own bank, the corresponding contacts of the ten banks must be connected together. Any one of the ten subscribers, then, who desired to call subscriber number 6, for instance, would select the sixth contact of his own individual bank. This is illustrated in Fig. 4. Here subscriber A is represented as having called subscriber B. The lines from A are attached to the fourth pair of bank contacts of each bank, while the lines from B are in like manner attached to the sixth pair of contacts. Subscriber A with his line wiper on the sixth contact of his bank in reality not only occupies the sixth contact of B's bank but also the sixth contact of the remaining banks in this system of ten. Since the lines of subscriber B alone are attached to the sixth contact, any other subscriber selecting that contact will signal B only.

FIG. 4.



Now consider a larger group of subscribers, a group of one hundred. The line terminals or bank contacts will now fill ten of these bank rows. These rows are superimposed one upon the other, somewhat as shown in Fig. 5. The number of the line connected to the first pair of contacts in the first, or lower row, would be 11; the number of the line connected to the second contact in this row would be 12; the next 13, etc. The number of the line connected to the first pair of contacts in the second row would be 21; the line connected to the second pair of contacts in the second row would be 22, etc. It will be noted from this that in a system of one hundred lines every subscriber's number would contain two digits: the first digit would indicate in which horizontal row of bank contacts his line terminal could be found, and the second digit would indicate the exact pair of contacts in this row.

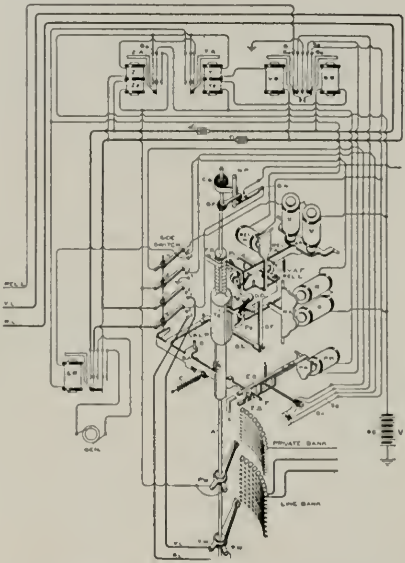
FIG. 5.



To get a rough idea of the method of obtaining a connection in a system of this size, we may again consider that each subscriber's line is connected to a pair of bank contacts and to a connecting machine, technically called a connector switch, somewhat after the fashion indicated in Fig. 5, which represents the connections for line No. 11. It will be noted that the important feature of this machine is the ratchet-wheel or hub *R*, which carries the wiper *W* previously represented in Fig. 3.

Fig. 5 also shows the rotary magnet with its armature *A* and pawl *P;* also the dog *D* for the retaining of the ratchet after each rotary step. The shaft on which the ratchet *R* is mounted is extended and carries another ratchet, *VR,* called the vertical ratchet. The vertical magnet is adapted to attract the vertical armature *VA,* which carries on its end the pawl *VP,* arranged to engage the vertical ratchet and to raise the shaft, and by means of it, the wiper one step whenever the magnet attracts its armature. The vertical dog *VD* is adapted to drop into place each time the ratchet is raised one step, and thus retain the wiper in position.

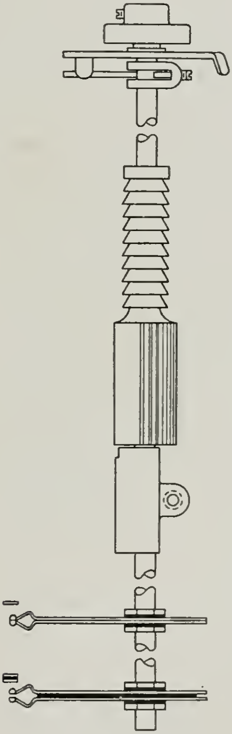
FIG. 6.



It will be noted, that, by means of the vertical pawl and ratchet, the wiper may be raised to a point opposite any one of the ten horizontal rows of bank contact pairs. Then, by using the rotary pawl and ratchet, the shaft may be rotated until the wiper rests on any desired pair of bank contacts in that horizontal row. Thus, if the vertical magnet should be intermittently energized three times and the rotary magnet five times, the wiper would be raised to the third row of bank contacts and rotated five steps, in this manner connecting line 11 to line 35. The apparatus is so arranged that subscriber No. 11 may intermittently energize the vertical and rotary magnets and control the movements of the wiper by turning the dial on his telephone, as has already been explained.

He is, therefore, equipped to operate his connector switch so as to place the wiper on the bank contacts of any one of the one hundred lines terminating in the group. In addition to the mechanism here shown, means are provided for him to signal any subscriber with whom he connects and talk with him. Means are also provided so that, when he completes his conversation and restores his receiver to the switch-hook, the dogs *VD* and *D* will be withdrawn, and the shaft carrying the wiper and ratchets will be returned to normal position by the action of a clock-spring and gravity.

FIG. 7.



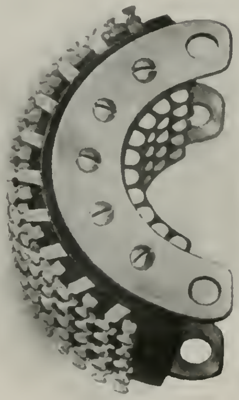
SWITCH SHAFT

In reality the circuits and mechanism of the connector switch are more complex than those shown here, but this figure illustrates the general principle, which is the main object of this paper. Fig. 6 shows graphically the mechanical parts and actual circuits of a connector switch commonly used.

Fig. 7 shows a drawing of a shaft with rotary and vertical ratchets and with wipers attached: Fig. 8 is a photograph of an actual bank, or rather half a bank, containing fifty pairs of bank contacts,—that is, five rows of ten pairs each.

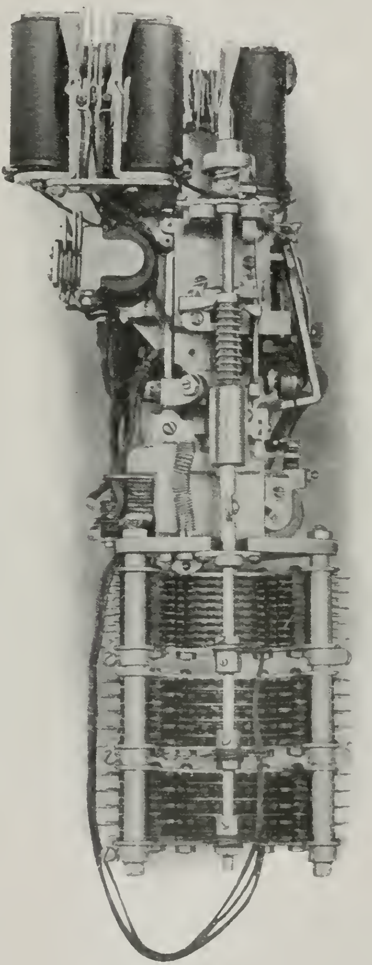
Fig. 9 shows a photograph of a complete connector switch with its shaft wipers, wiper cords, coils, relays, and banks. The two lower banks are called the line banks. Each bank contains five rows of ten pairs of bank contacts. Two separate line banks with two sets of line wipers are employed, in order to give more space between the vertical bank rows. The lower line bank rows thus represent the odd levels from one to nine, the upper the even rows from two to ten. The top bank is what is technically called the private bank. This bank, together with the upper wiper called the private wiper, is used to establish a guard over a completed connection. That is, if the line wiper of a connector switch should rest on the terminals of line No. 48, for example, then the private wiper of this switch would rest on contact No. 48 in the private bank, and in this way would complete circuits which would establish a guarding potential on this contact wherever it appears in the banks of any other switches; consequently any other subscriber attempting to call

Fig. 8.



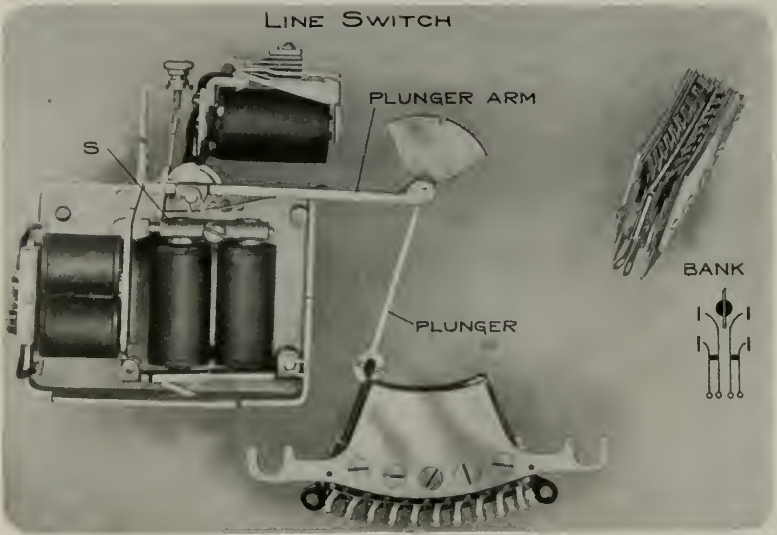
No. 48 while it is busy would automatically be given a busy signal. This "busy" signal consists of an intermittent buzzing sound transmitted to the subscriber's ear, and is the same as that often used in manual telephone systems.

FIG. 9.



Although for the purpose of explanation I have supposed that there would be one connector switch connected to every subscriber's line, this is not the case in actual practice. The switchboard would be entirely too expensive to compete with manual switchboards if it were necessary to provide one hundred of these connector switches for a group of one hundred subscribers. A switchboard is, therefore, so arranged that only enough connector switches are supplied to provide for every subscriber who might desire to use one at the busiest moment of the day. It has been found from experience that ten of these switches will generally be enough for the maximum demand of one hundred subscribers, even in a very busy central office. Having determined how many of these switches are actually needed, the next step is to provide some means for placing an idle connector switch at the disposal of any subscriber who might wish to make a call. This is done by having each subscriber's line terminate in what is called a line switch. This is an inexpensive device, a photograph of which is shown in Fig. 10.

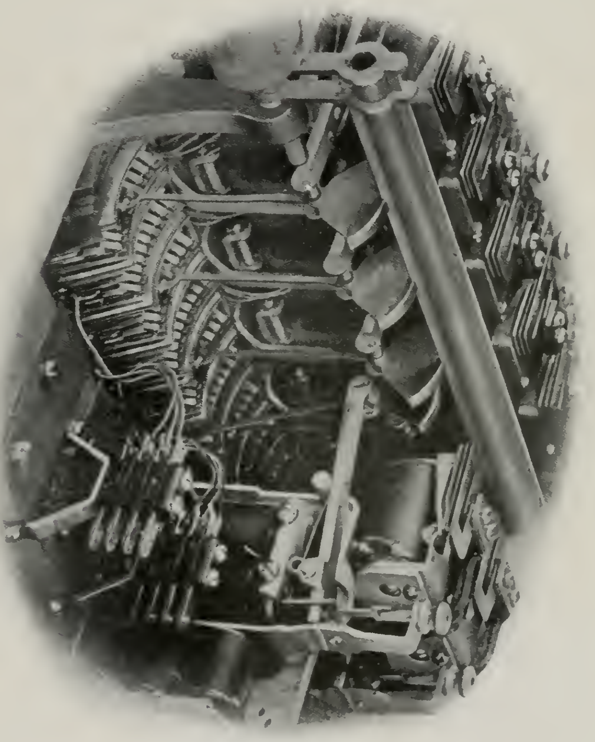
FIG. 10.



It will be noted that the essential feature of this switch is the plunger arm, which is pivoted near one of its ends, and which carries at its other end an arrow-like plunger. This plunger is pivoted so that its lower end may be swung back and forth over the bank. This bank consists of ten sets of bank springs; each set is made up of four movable springs and four contact plates, as shown in the lower right-hand corner of the illustration.

The line switch is so designed that when the trip magnets are energized it will release the plunger arm and allow it to plunge into a particular set of bank springs over which it may be poised at the instant. The effect of this is to press the bank springs against their contact plates and thereby close certain circuits which will be referred to more fully later. When conversation is completed, the plunger is automatically withdrawn from the bank and returned to normal position. Fig. 11 shows how these line switches are mounted in rows, so that the notch of the fan-shaped head of each plunger engages a knife-edge on what is called a master-switch shaft. This enables the mechanism controlling the master-switch shaft to control the plungers and to swing each plunger back and forth over its bank. These

FIG. 11.

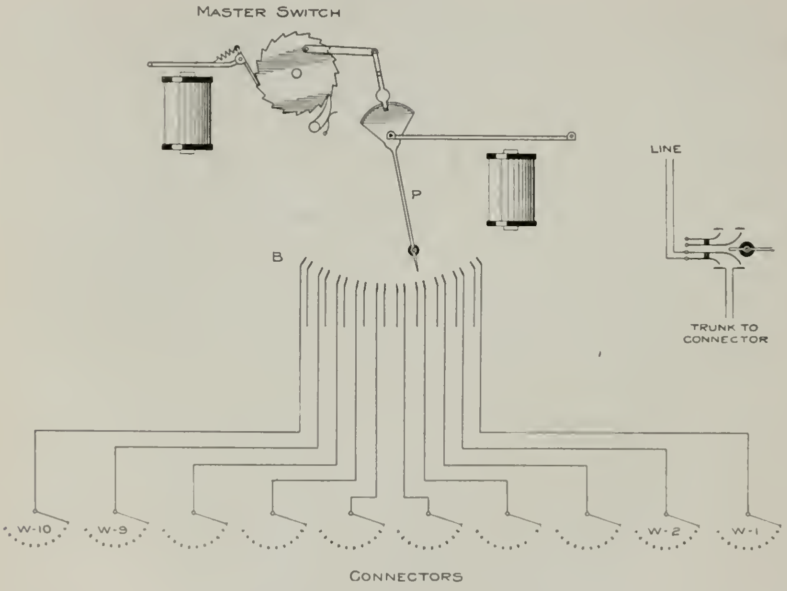


plungers are not in constant motion, but are moved step by step as required. Ordinarily one hundred of the line switches are mounted together in a group, so that the plungers of the entire one hundred are controlled by one master switch.

It will be noted that all plungers which are in engagement with the shaft are in alignment, and that when the shaft swings them the whole one hundred will swing as one unit.

With this explanation of the line switch mechanism, the purpose of this apparatus can be readily understood by reference to Fig. 12. In this figure *P* represents one hundred line switch plungers in alignment one behind the other, *B* represents the banks of these line switches which are also placed in alignment one behind the other. The first set of bank springs in each of these one hundred banks is connected, as illustrated, to a connector switch and its wiper *W*-1,—that is, the first set of bank springs in the entire one hundred is multipled together and the entire one hundred are connected to one connector switch. In a similar manner the second set of bank contacts in each of the one hundred banks is connected to another switch with its wiper *W*-2. The third set of bank contacts is multipled together and

Fig. 12.



connected to a third switch with its wiper *W*-3. In this way ten connector switches with their wipers, *W*-1 to *W*-10, are connected to the ten different line switch bank multiples. It will be noted that in the illustrations the plungers *P* are all poised over bank contacts No. 4. If now the plunger of switch No. 1 should be released, it would connect line No. 1 through to connector switch No. 4. It will be noted from the sketch in the other part of the figure that when the plungers are in the bank the two movable line springs are pressed against the two contact springs connected to the trunk leading to the connector switch. The instant that the plunger of switch No. 1 is thrust into the bank, the master-switch mechanism is energized and carries the remaining ninety-nine plungers one step forward so that they will be poised over bank contacts of trunk No. 5. This movement is carried out by a ratchet-wheel with its armature and pawl as indicated in the figure. The ninety-nine plungers now remain poised over trunk 5 until another subscriber calls. We will suppose that this is subscriber No. 2, and instantly the plunger of switch No. 2 is thrust into the bank contacts No. 5, and subscriber No. 2 is thus given access to connector switch No. 5. The master switch is immediately energized and carries the remaining plungers forward over trunk No. 6. In this way the master switch with its shaft always keeps the plungers of the idle lines poised over the bank contacts of trunks leading to idle connector switches. When the plungers have been swung as far as bank contacts No. 10, and this trunk has been occupied, they then start back again step by step to trunk No. 1. If on returning, trunk No. 9 is still busy, the master-switch automatically keeps the plungers in motion until a trunk leading to an idle connector switch is found. A subscriber's line switch is operated the moment that he pulls his dial, and before the dial starts to return he is already connected through to an idle connector switch, which is operated as already described to put him in connection with the particular subscriber he desires.

The real work of picking out the desired line is done by the connector switch, as described in the earlier part of this paper. The whole purpose of the line switch is to give the calling subscriber access to an idle connector. This makes it possible to reduce the number of connectors to the largest number ever needed at the busiest moment. One hundred subscribers are thus served by ten connector switches.

FIG. 13.

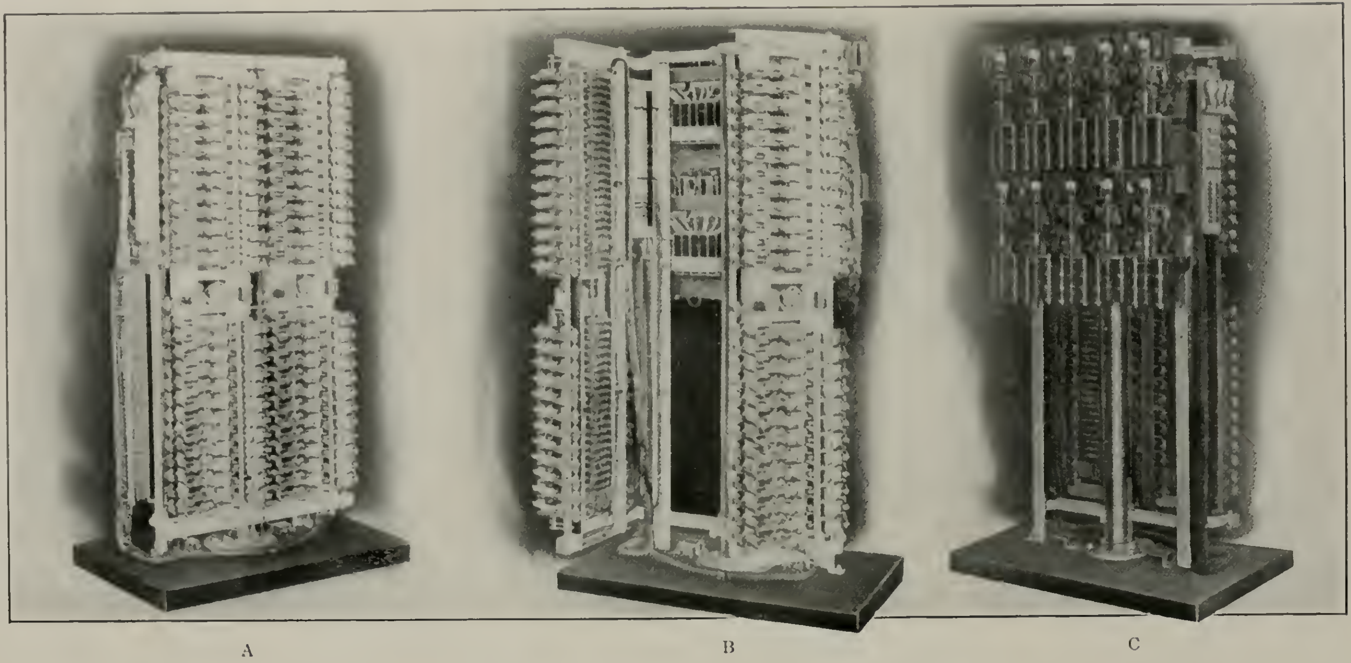


Fig. 13 shows three views of a complete board equipped with apparatus for one hundred subscribers. View *A* shows the one hundred line switches arranged in four groups of twenty-five each, the plungers of each group of twenty-five engaging with one section of the master-switch shaft.

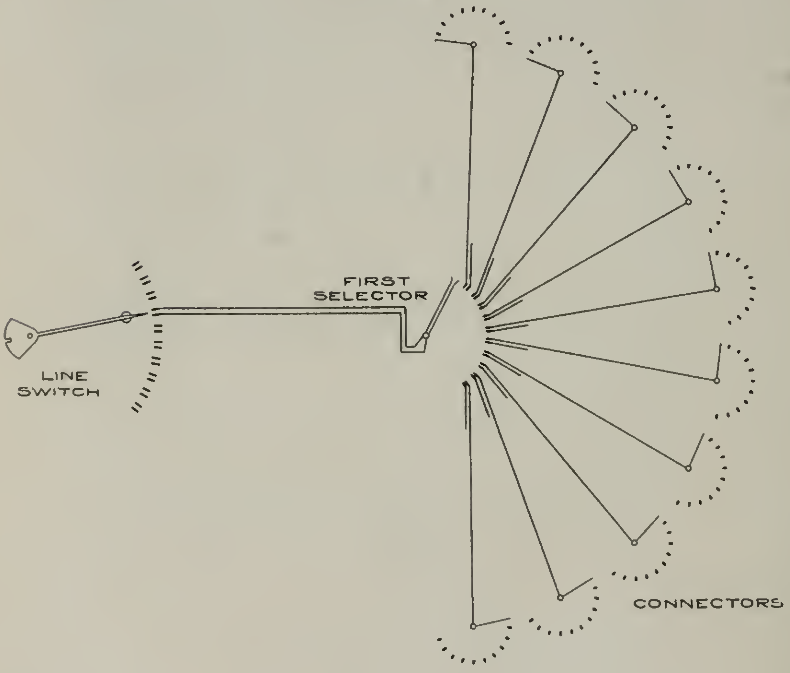
There are two master switches shown mounted on the board, but only one is used at a time. The other is held in reserve so that in case of an accident it can immediately be thrown into engagement with the shaft and the disabled master switch be disconnected. View *B* shows that the line switches are mounted on two swinging shelves in such a way that the shelves may be turned outward on their hinges, giving free access to the cabling, bank wiring, etc., on the rear of the shelves. View *C* shows the other side of the switchboard, on which are carried connector switches mounted in two rows of five switches each.

A system of more than one hundred subscribers—for example, a system of one thousand lines—is made by using ten of these one hundred line switchboards and installing apparatus for interconnecting between them. The machines which do this connecting are called selector switches. In general appearance they are very similar to the connector switches. The selector switches are interposed between the line switches and the connector switches, so that in a system of one thousand lines capacity a subscriber's line switch when it operates connects him through to an idle selector switch, instead of to an idle connector switch as previously described. The scheme is illustrated in Fig. 14.

To the left of this illustration is a line switch belonging to one of the ten one hundred groups of this one thousand line exchange. When the subscriber whose line is attached to this line switch pulls his dial, his line is immediately connected by the plunger to an idle trunk leading to one of ten selectors, exactly as in the previous case he was connected to one of ten connectors. As represented here bank contacts No. 4 are connected to a selector switch in the centre of the figure. The selector switch has a bank of one hundred pairs of contacts arranged in ten horizontal rows of ten pairs of contacts each. Each pair of contacts in the lower row—that is, row No. 1—is connected to one of the connector switches on one of the ten line switchboards used in the system, and which we will call the one hundred line group. Each pair of contacts in row No. 2 of the selector banks will be connected to a connector switch on another one of the ten line switchboards, which will be designated as the two hundred line group. In like manner ten trunks from the ten pairs of contacts in row No. 3 of the selector banks will extend to ten connectors in the three hundred line group, and so on through the ten rows.

The operation of a selector switch is a little different from a connector, since its function is not to select a definite contact, but only to select one trunk out of ten trunks any one of which will answer the purpose providing it is not occupied. That is, each level of a first selector bank represents a one hundred group in a one thousand exchange with ten pairs of trunks from each level to its particular one hundred group. Any one in that one hundred group can be reached over any one of the ten trunks, so that it is not necessary for the subscriber to pick out a particular trunk, but only one that is unoccupied. Since he cannot know which one is vacant, the selector switch is made to do this for him.

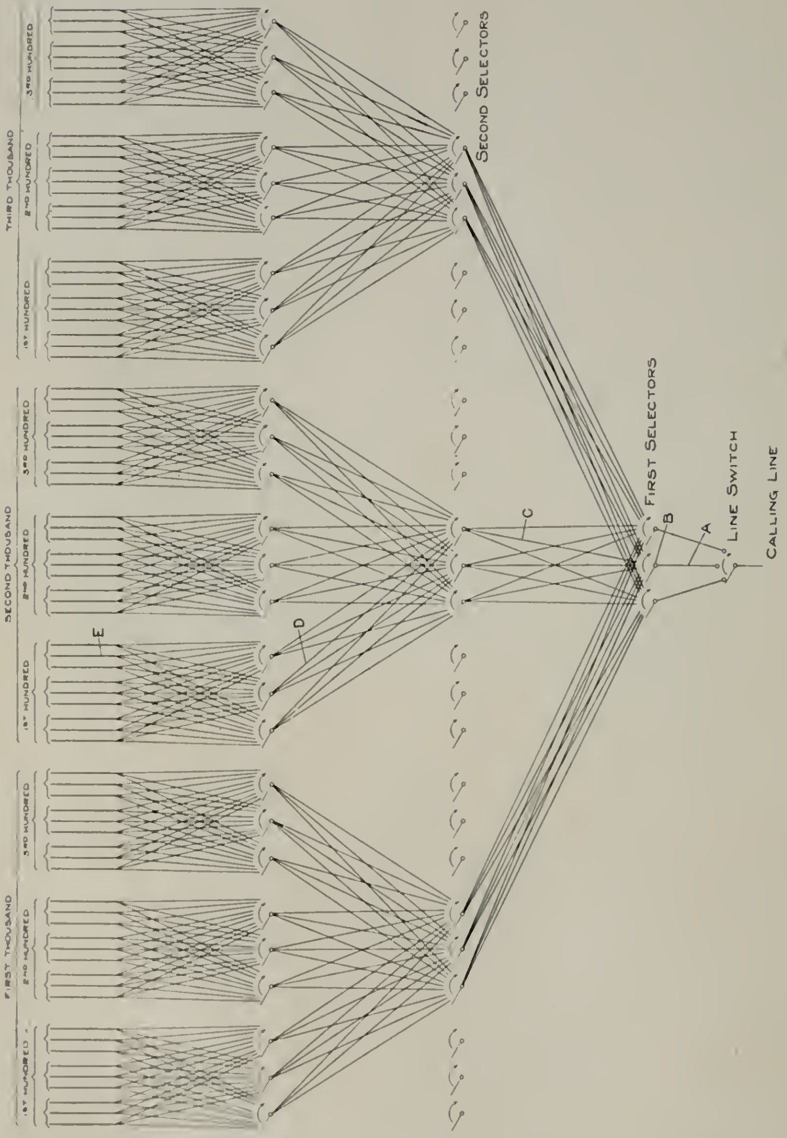
Fig. 14.



As in the case of the connector, a private bank is formed for the selector identical with that of the connector and for a similar purpose. When one subscriber then makes a call and obtains a certain trunk, a guarding potential is thrown upon that contact of this additional bank which corresponds to the particular line contact occupied. The selector in a simple manner is made to cut in automatically on the first contact of any particular level after the vertical impulses have been completed. The wipers of the selector of a second subscriber from the same group cutting in on the same level, instead of remaining upon the contact the multiple of which is already occupied, will rotate automatically to the second contact or until they engage a contact the corresponding private contact of which is not grounded by any other switch. Groups are therefore represented by one digit instead of two,—that is, by the digit which represents the proper level of the selector bank. To illustrate, a subscriber calling 752 would impart seven impulses to his group selector, which would then seize upon the first of the ten vacant trunks of the seventh level of his bank and connect his line with a connector in the 700 group. Five and two impulses respectively would then connect him with the No. 52 pair of contacts of the connector bank to which the lines of the called subscribers are attached.

A ten thousand system would consist of ten groups of one thousand, each one thousand group consisting of the ten groups of one hundred just described. The following diagram, Fig. 15, is an illustration of the trunking of an exchange having an ultimate capacity of ten thousand. A first selector in this case will be necessary to select thousand groups, the hundred groups of which will be selected by a second selector. One calling line is here represented attached to one line switch. This line switch has access to ten trunks, of which only three are here shown leading to three first selectors. Three levels of first selector banks with three trunks from each level lead to three second selectors in each of their respective thousand groups. In like manner three levels of the second selector banks with three trunks from each level lead to the connectors of their respective hundred groups in each thousand. From these connectors the line normals from each of these bank levels in each of the hundred groups extend to the various lines. As represented in this figure, each calling line has access to one line switch, ten first

FIG. 15.



selectors, one hundred second selectors, and one thousand connectors. To trace out a call explicitly we will assume that a subscriber desires number 2132. The line switch, we will assume, seizes the second trunk line *A*, connecting the calling line with the second first selector *D* of the ten selectors belonging to the particular hundred group in which the calling subscriber is located. The first digit, 2, of the calling number indicates that the called subscriber belongs to the second thousand group. Consequently, the calling subscriber raises the wipers of his first selector to the second row or level of contacts of his bank, and seizes automatically, say, the third trunk line, *C*, assuming that the first two trunks are busy. His line now being connected to the third second selector, the subscriber causes the wiper of this selector to cut in on the first level of second selector bank contacts, since the digit 1 indicates that the subscriber wanted belongs to the first hundred group. Assuming that the first trunk is engaged, the wiper will stop on the second trunk, extending the calling line now to the second connector of the ten connectors in the first hundred group. Raising the connector wiper to the third level and rotating it to the second contact, connection is then completed with the called line *E*, the calling number of which is 2132.

This completes an elementary exposition of the principles of automatic telephony. The question may now arise, What is the excuse for the automatic exchange? What are its advantages? As with every question, there are always two sides, and the side adopted is generally the one most closely connected with one's business interests. Whether we want to be impartial or not, it is a very difficult matter to exercise an unbiassed judgment unless our interests lie far enough away to give us a good perspective. One of the reasons of Mr. Strowger for designing a system was to get rid of the telephone girl. Others have seemed to find the girl operator an attraction. However the case may be, there are very many substantial reasons for the existence of an automatic exchange which even the stanchest supporter of the manual systems cannot gainsay. There are two stand-points from which this subject may be viewed,—namely, that of the subscriber and that of the operating company,—but they are so interrelated that no attempt at distinctions will be made.

In automatic systems, instead of the manual switchboard operator is substituted a switchboard attendant who is able to take care of the necessary apparatus for one thousand subscribers. and keep it up to its highest efficiency. In consequence the labor cost is much decreased, less expensive quarters are required, the cost of fuel and lighting is reduced, and the accessories attendant upon the employment of operators are eliminated. The efficiency of an automatic exchange of small size is maintained at no greater expense than that of the manual, while in larger exchanges this item is much less than in a manual system of equal size. Increasing the capacity of the automatic exchange is a very simple matter and does not add to its complexity. The cost of operation per line increases slightly with the growth in the number of subscribers and in an arithmetical ratio. This increase in manual systems, on the contrary, is geometrical in nature and large enough to be a serious handicap.

The automatic telephone is a cosmopolite and speaks to every nationality in its own language. Connections are quick, disconnection instantaneous; consequently the same number of trunk lines in an automatic exchange represents a greater capacity for a certain number of calls within a fixed time limit than in a manual system. Regardless of the demand, the same facility in giving connections is maintained at all times. Confusion is impossible. A large number of subscribers may call simultaneously, at any hour of the day or night and each call will receive immediate attention and be taken care of with the same facility and dispatch that would be given were there only one call. When a line is busy, the subscriber is so informed at once, and he can repose the utmost confidence in the source of his information. Moreover, the service is secret. The frequent clicking, the lack of clearness on the line, the annoyance caused by knowing that a third person is intruding where three is a crowd is never known.

The automatic exchange probably never wears out. It may go through a process of renewal and aging, such as the human body experiences with a fixed time limit, but its comparative youth precludes this knowledge. The main part of the mechanisms deteriorates very slowly and such parts as are subject to wear and tear are easily replaced as needed, with the result that the exchange may be retained in its original efficiency for an indefinite period or until the march of progress requires its replacement by an improved equipment. Since, no matter what the size, the exchange is composed of groups of smaller exchanges connected by a certain percentage of trunk lines, these groups may be scattered over a large area. Thus by establishing these groups at the various local centres of a city or community, the first cost of an installation is greatly reduced and the expense of maintenance materially lessened. As no operators are needed, these groups may often very profitably consist of only a single unit of one hundred subscribers and may be housed in any accessible quarters. In cases where ten per cent. of trunk lines is not sufficient to transact satisfactorily all business during the period of maximum calls, it is an easy matter to increase the number of trunks as desired. This may be done locally, wherever the activity is greatest, or may be carried throughout the exchange. These are some of the reasons for the automatic exchange which must appeal to all. There are others which must be left to individual choice, and still others which belong to the province of the engineers and students of the science.

PETROLEUM IN 1908.

The great gain in the production of petroleum in 1907 over 1906 required such a drain on all the great pools and developed so large a stock of unused crude oil that a further increase in 1908 was not logical, as a matter of either finance, trade requirements, or available petroleum resources. As the year went on, unprecedented floods in May and June and again in November brought disaster to the pipe lines of Oklahoma; and these storms also left a record of numerous oil tanks destroyed by lightning. In the Eastern fields the severe drouth also seriously interfered with well drilling. The decline in production in the Glenn pool and in various Texas and Louisiana pools increased the likelihood of a total smaller than in 1907.

Nevertheless, the actual record of the year shows a total beyond all records—between 175 and 180 million barrels, compared to 166 millions in 1907, or between 5 and 9 per cent. increase. The total value is proportionately greater still, for the price of the product in California increased and it remained steady in other fields, except the Gulf, where a comparatively groundless fear of overproduction from the new Markham and Goose Creek fields caused depression.

The increases came from the steady growth in Illinois and California. Neither field showed phenomenal development. California responded to the higher prices consistent with depleted stocks, and Illinois showed the continued effect of the great investments of the previous year in this new territory.

The year, however, had its sensations. They came in midsummer. On July 2 a large gusher was drilled in at Goose Creek, Harris County, Tex., and three days later a gusher of the spindletop type came in at Markham, in Matagorda County. This turned the attention of the oil producers in the Gulf field significantly farther south.

July 4 proved memorable in three widely separated regions. At Anse la Butte, La., a large gusher known as Lake No. 9 was drilled in. On the same day the Pearsons in Mexico opened a well that assumed the proportions of a volcano and made a new world's record for an outburst of oil and water. Incidentally it is interesting to note that on the same day the Oil City well at Tustanowicz produced the record spouter for Galicia.

The elasticity of the American oil trade is shown by the fact that stocks did not increase as much as would have been expected from the great product. The preparations of the year before led to better ability to transport the product to points of consumption.

SECTION OF PHOTOGRAPHY AND MICROSCOPY

(*Stated meeting held Thursday, February 11, 1909.*)

HIGH TIDES OF THE BAY OF FUNDY.

BY
J. W. RIDPATH,
Member of the Institute.

Before considering these unusually high tides, perhaps it would be well to speak, in a brief way, of the principal causes of tides and why they are higher in some places than in others.

It is generally agreed that the earth is a globe, slightly flattened at the poles, the shorter or polar diameter being about 26 miles less than the longer or equatorial diameter. It if were possible to measure the extreme diameter of the earth together with its surrounding atmosphere, probably the difference between the polar and equatorial diameters would be found much greater; for the atmospheric tides no doubt greatly exceed the oceanic tides.

The shape of the earth, that of an oblate spheroid, flattened at the poles, is that which would naturally be assumed by a rapidly rotating liquid or plastic body. As a globe of fused material, the various substances of its composition would naturally arrange themselves very much in the order of their density; the more dense material at the centre. It has been found that the specific gravity of the earth as a whole slightly exceeds 5, say five-eighths that of iron, while that of the rocks on the surface ranges from 2.5 to 3, indicating that the interior of the earth is much more dense than its outer portions.

It may be that the earth is in the main a solid or rigid mass solidified by pressure, with only an envelope or superficial layer of less compressed or more plastic materials, composed largely of sand, clay, and water; the latter, owing to its greater mobility, readily flowing toward the equator—the part of greatest velocity in the rotary motion of the earth. As if in accordance with this theory, which is disputed by some, we find that the majority of the important rivers flow toward the equator, one, the Mississippi, flowing up hill in order to reach its southern outlet; or to be more exact, the mouth of the Mississippi is farther from the centre of the earth than is its source.

Tides are the alternate rising and falling of the waters of the ocean at regular periods; that is, twice every twenty-five hours, nearly. Other things being equal, tides are higher at the equator and lower at the poles.

The principal cause of tides is the attraction of the sun and moon upon the waters of the ocean. But for this attractive influence, the waters of the ocean, having found their level, would cease to heave and swell, as they now do, and would remain undisturbed, save as the wind, by wave-action, might disturb the surface.

The distance of the moon from the earth is about thirty times the diameter of the earth, hence her tidal attraction is considerable. If a man could travel around the earth near the equator nine and one-half times, he would have travelled as far as to the moon. The sun, although much larger than the moon, is so far away that its tide-producing force is much less than that of our satellite; the relative effect being estimated as approximately one to three, in favor of the moon. The tidal impulse caused by the sun's attraction passes around the earth in twenty-four hours, while that of the moon requires nearly twenty-five hours to complete the circuit; therefore we have twice in each lunar month, tides that are higher than the mean.

The sun and moon act in the same direction when the moon is new and when it is full, causing high or spring tides, as they are called. When the moon is in her quarters the sun and moon act at right angles to each other, causing low or neap tides.

In obedience to gravity the waters nearest the moon rise and form tides. These waters are of course 4000 miles nearer the moon than is the centre of the earth; and as the water-particles move easily, owing to the mobility of water, they are drawn up, forming a protuberance above the mean form of the earth. The waters on the opposite side of the earth are as much farther away from the moon, hence they are equally less attracted, and form a similar protuberance. Thus, the waters in a straight line from the moon bulge from the earth's surface, as the particles of water are free to move, while the particles of land are not. The waters nearest the moon move because they are drawn from the solid part of the earth, and the waters on the side farthest from the moon bulge because the solid earth is drawn from them; hence opposite sides of the earth always have similar tides whether high or low, at the same time. As a necessary consequence of the elevation of the water in the regions nearest to, and most remote from, the attracting body, there is a corresponding depression below the mean level of the sea at points ninety degrees therefrom.

The tide-producing influence travels at the rate of about 1000 miles per hour, therefore if there were no interfering land, and the ocean were deep enough,—about fifteen miles,—the tidal elevation might travel at the same rate. It has been found, in fact, that the tidal movement varies with the depth of water in the ocean, flowing much more slowly in shallow basins. The following table was published a few years ago to illustrate this phase of the subject:

10 feet deep	12.2 miles per hour
60 feet deep	30.0 miles per hour
100 feet deep	38.7 miles per hour
1000 feet deep	122.3 miles per hour
6000 feet deep	299.5 miles per hour

In a bay or indentation, decreasing in width from its entrance toward its head, the tide rises higher from the mouth upward, due principally to the fact that the vertical movement is partly changed into horizontal movement owing to the shoaling of the bottom. The highest points of these tide-waves usually fall behind the vertical of the attracting bodies because of the friction produced by the varying depths of water in the ocean, especially near shore lines.

At some places on the Atlantic coast the tide pours onto the shore with prodigious violence. On the rocky coast of Maine and the eastern coast of Nova Scotia the huge Atlantic waves and violent tidal movement beat with enormous force, but owing to the hardness and solidity of the rock but little harm is done, except to ships when they venture too near shore.

On the eastern coast of Nova Scotia the waters of the great tidal uplift are not confined between rocky barriers, hence they are free to spread northward to the gulf of St. Lawrence or southward opposite the United States coast. At Halifax, about midway along this eastern coast, the tide seldom rises above seven or eight feet. But on the coast of Massachusetts, New Hampshire, and Maine, the tidal waters are somewhat confined by Cape Cod on the south and Nova Scotia on the northeast. Hence the incoming tidal waters are forced up the conical passage between New Brunswick and Nova Scotia giving rise to tides of great height.

The Bay of Fundy, noted for its dense fogs and high tides, extends nearly 200 hundred miles inland from the ocean. Its shores are generally high and rocky, rising like great walls against the sea; causing dangerous bores in the upper reaches. The bore is the first rush of the incoming tide. In some places the shore presents a very bare appearance at low tide owing to its long expanse of mud flats.

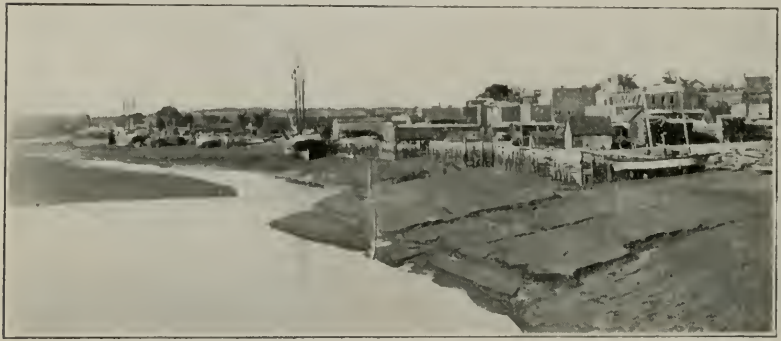
Yarmouth, located near the southern extremity of Nova Scotia, at the mouth of the Bay, has long been noted for its shipping and ship-building. Although its tides are not so enormous as at points farther up the bay, they are sufficiently high to astonish a stranger, who at low tide cannot see sufficient water to float the vessels made fast to the docks. At the entrance of the bay, the tide rises to the height of eighteen feet; and as Yarmouth is virtually at the entrance, very considerable tides may be expected.

At St. John, about one hundred miles farther up the bay, coasting schooners float in twenty-five feet of water, where six hours later they are high and dry, their decks ten to fifteen feet below the level of the wharves. It is here that the celebrated reversing fall is located. It is caused by a rock barrier, over which the fresh water of the river flows as it is discharged into the harbor through the narrow rocky gorge forming beautiful waterfalls of about fifteen feet when the tide is out; but when the tide turns the salt water of the incoming tide gathers force and rises much above the barrier, and the flood is forced backward, causing a reversal of the falls with the water actually pouring upstream.

Farther up the bay we have Cape Blomidon, a mass of trap rock on red sandstone; part of the North Mountains range rising at Look-off, a nearby point, to an altitude of 700 feet. At the Cape this promontory is about 500 feet high. North of Blomidon we find Cape Sharp, the opposite rocky barrier, some three miles distant, which, like Blomidon, has successfully withstood the impetuous onslaught of the roaring tides for untold ages. To beat down through this "gut" as it is called, against wind and tide, would indeed be a perilous adventure. Through the narrow passage the incoming water pours with great violence, flowing in an easterly direction until the entire Basin of Minas has become an inland sea. The enormous volume and great force of this tide indicates in some measure the tremendous power of the tidal forces.

Near the junction of Minas Basin and the river Avon are located Kingsport, Horton, and Hantsport, ship-building towns. Here ships of considerable size are readily repaired in front of a wharf which serves as a natural dry-dock when the tide is out.

FIG. 1.



Negative by Edson Graham.

Windsor, tide out.

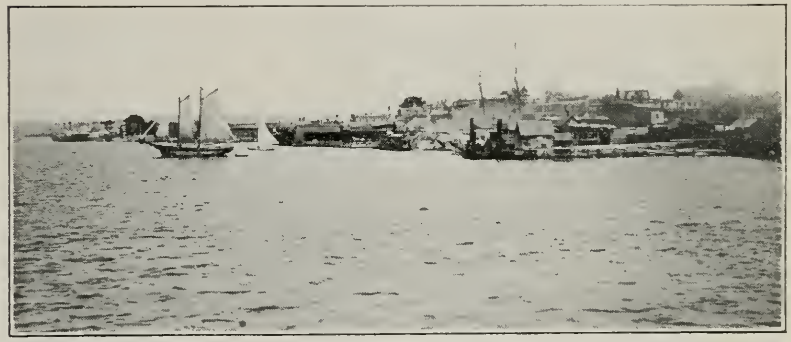
Windsor, located upon the river Avon, some ten miles from Minas Basin, is a picturesque old town, with good streets and beautiful drives leading into the surrounding country. It has long been noted for the excellent quality of gypsum which is mined there and exported to points on the Atlantic coast, much coming to Philadelphia. Windsor is a good point from which to view and study the tides, which are over thirty feet high, although at Halifax, about thirty miles distant on the Atlantic coast opposite, they rarely exceed seven feet.

Some forty miles farther up the Basin of Minas, the Shubanacadie River enters the bay at Maitland. This river is also comparatively small when the tide is out, but the high-water mark is clearly shown about forty feet up on its steep rocky easterly side. It is said to be the highest tide-water river in the world.

About twelve miles farther up the bay, near the lower village of Truro, the bay is only about half a mile wide, with no salt water at low tide. A mile farther, the high ground on either side approaches sufficiently near to allow a bridge to be readily built. After passing the bridge, a basin about a mile in length is reached. This basin is fed with fresh water by the North River and Salmon River, both small streams. Before the bridge was erected, ships of small size were built here and floated down to deeper water when the tide was in.

At Moncton, New Brunswick, the Petitcodiac River, at low tide, is only a narrow channel bordered with wide mud-banks, which reach from the shore to the narrow stream of fresh water. When the incoming tide of the northern arm of the Bay of Fundy reaches the narrow part of the river, the water is forced back with great violence and a tidal wave, or "bore," from three to six feet high is formed. At this point the tide sometimes reaches the enormous height of sixty feet.

FIG. 2.



Negative by Edson Graham.

Windsor, tide in.

The first intimation a visitor has of the incoming tide, is a dull, rumbling sound, like that of a distant waterfall combined with the rolling sound of an approaching train. As the tide approaches the sound increases, until finally the "bore" is seen, coming as a huge rolling wave, from one to six feet high, slightly convex in front, owing to the shore friction. The speed of this advance wave, or first rush, is described as that of a race horse; and indeed it is such as to rapidly wear away the mud banks in the channel bed, giving a decidedly red color to the water.

SOME MODIFICATIONS OF PLATINUM PRINTS.

BY
JOHN BARTLETT,
Editor, Bulletin of Photography.

Painters seem to prefer a print in black and white with intermediate gradation, asserting that such tones are more suggestive from their purity of color range than any other tints.

Rich engraving is certainly capable of translating the color of the original painting better than the most skilfully executed colored lithograph, chromo, or even a well-done three-color-process print, and so the painter is always more charmed by a beautiful black and white platinum than he is by a sepia or other tone print made in the same medium. But photographers and the public in general prefer sepia or brown tones.

It may be that the really inadequate black of a bromide of silver print (velox) is the cause of the preference.

We have heard many maintain that there is practically no difference between the blacks of platinum and bromide, but the difference is generally acknowledged, when, for comparison, one is placed against the other. However as the demand for other than platinum black is predominant, it is necessary to modify the tone to suit the prevalent taste.

One thing is essential to secure the beautiful "black" of the platinum and that is the employment of perfectly fresh platinum paper. We recently came across a lot of stale platinum paper, which the owner declared was fit only to go to the reducers for the extraction of the valuable metal, or to be used as a tinted background in artistic mounting. At our request he allowed us to experiment with some of it before its ultimate condemnation.

This paper presented anything but a promising aspect, being much tinted by age. With normal oxalate development it gave weak flat images scarcely differentiating themselves from the ground of the paper. We next tried what effect an alkaline development would have. Carbonate of soda at normal temperature (about 70°) was employed. The development proceeded somewhat rapidly and gave better tones than with oxalate, but invariably the image lacked sharpness and distinctness; the reduced platinum seeming to spread over into the margins of the white ground. Outside those limits the ground was pure; the black part of the image also partook of a rusty appearance. Dilution or concentration of developer seemed to make but little material improvement, nor did ammonium or potassium better conditions.

By experimenting both in printing and in developing we hit upon a method of improvement in respect to sharpness as well as color, but not to the extent as far as color is concerned as with fresh paper, sufficient, however, to make very presentable results comparing most favorably with the bromide print.

The exposures were somewhat shortened (about one-third less than with the fresh paper) and the printing was done in the sun.

The alkaline bath should be constituted as follows: Saturated solution of sodium carbonate diluted with equal volume of water, to which add one-eighth the bulk of a saturated solution of common alum. The slight milkiness produced does not interfere with the action on the print, but it is best to have considerable solution in the tray.

The development is effected by applying the print face down to the surface so as to avoid wetting the back of the print which interferes at the part with the intensity of the tone. Avoid, however, the formation of air-bells on the surface. Allow the paper to remain in contact with the developer only a few seconds (not more than fifteen seconds), as the object is to keep the impression on the surface. Raise the print up without sliding after the expiration of the time and place it upon a sheet of glass, noting the progress and extent of the action. The slight excess of fluid on the surface may be directed to any spot needing attention.

When the proper intensity is reached place at once in the acid bath (1 : 50) and let it remain there for five minutes or more, then transfer to another acid bath and wash as usual. Do not fail to apply first the acid baths before washing.

The tones obtained by this method will be found most satisfactory. The black has a slight tendency to blue or purple.

Another plan for utilizing stale platinum (published about a year ago), consists in the use of a small percentage of neutral chromate of potassium. We are thus enabled to secure quite brilliant prints from very old paper. The samples we experimented with dated three years back. The quantity of the chromate of potash should not exceed one-half grain to the fluid ounce of oxalate developer, which is used cold. Care should be taken not to confound the chromate with the bichromate, as the action of the latter salt is too energetic, eating away the half tones of the picture.

The chromate (neutral salt) may also be used in less quantity and perferably in a five per cent. solution as a retarder or restrainer for over printed fresh paper platinum proofs. It gives the necessary contrast and prevents flatness. A couple of drops (5 per cent. solution) to the ounce of developer is quite sufficient. The developer here also should be used cold, not over 60° or 70°.

Various means have been suggested for improving the condition of under-printed platinum proofs. One plan is to first soak the print in pure water and then evenly spread glycerin over the face to be followed by a weak acid bath of chloride of gold. This of course after development.

Dr. Vogel's method with chloroplatinite of potassium did not give me favorable results. The tone was too bistre or rusty looking.

Dr. Liesegang's plan is much to be preferred. After the developed print has passed through the acid baths, and has been thoroughly washed, it is placed in a bath composed of hydroquinone, citric acid and water, to which a few drops of a 60 grain solution of silver nitrate are added—which acts as an intensifier. The slight clot formed on addition of the silver does no harm. On completion of the intensification, wash the print and immerse for five minutes or more in a weak hyposulphite of soda bath.

The deposition of the silver on the platinum basis may now to advantage be followed by the formula recommended by Dr. Vogel. Gold and uranium can also be employed with prints so intensified.

A gold bath with sulphocyanide of potassium (similar to the well-known combined bath used in toning silver prints) may be advantageously employed to modify further the tone. The color so obtained is a rich bluish black.

The print treated with uranium nitrate followed by ferricyanide of potassium gives quite pleasing brown tones. The question of permanency of such prints might be agitated on account of the presence of the silver salt.

The ordinary black developed (normal) platinum print has always been regarded as permanent as the platinum black itself, and the fading sometimes experienced is blamed on faulty manipulation, to the presence of the traces of iron in the paper, which persist despite the application of the acid baths with a view of its elimination. But while we are not prepared to positively say that modified platinum prints are as permanent as untouched prints, we might venture to affirm that they have as good a chance to escape the vicissitudes of things as sepia platinums where mercury is present either in coating or applied to the developer.

PRESENT CONDITION OF THE COUNTRY'S FOREST RESOURCES.

FEW people have anything like a clear idea of the amount of forest wealth left in this country. Those who think at all about this natural resource which has assisted in material development since the landing of the first settlers are usually too much influenced by the condition of that particular State or section in which they are most familiar.

If they live in a much deforested or a treeless region, the people usually imagine that the country's timber supply is even more limited than is actually the fact; on the other hand, with those whose homes are located in a section where a pinch in timber has not been experienced, the feeling is likely to be altogether the other way, and some become so indifferent at times as to think that there is really not much reason to worry about a timber problem. Both can profit by a reading of the actual facts.

The forests of the United States now cover about 550 million acres, or about one-fourth of the land of the whole country. The original forests covered not less than 850 million, acres, or nearly one-half.

The forests owned by the Government cover one-fourth of the total forest area, and contain one-fifth of all timber standing. Forests privately owned cover three fourths of the area, and contain four-fifths of the standing timber. Besides having three times the area and four times the forests, the timber land privately owned is generally more valuable.

Forestry, or conservative lumbering, is practiced on 70 per cent. of the forests publicly owned and on less than one per cent. of the forests privately owned. This covers the country's forest resources as they stand to-day. Senator Smoot, chairman of the section of forests of the National Conservation Commission, in outlining the future has said:

"By reasonable thrift, we can produce a constant timber supply beyond our present need, and with it conserve the usefulness of our streams for irrigation, water supply, navigation, and power.

"Under right management, our forests will yield over four times as much as now. We can reduce waste in the woods and in the mill at least one-third, with present as well as future profit. We can perpetuate the naval stores industry. Preservative treatment will reduce by one-fifth the quantity of timber used in the water or in the ground. We can practically stop forest fires at a total yearly cost of one-fifth the value of the standing timber burned each year, not counting the young growth.

"We shall suffer for timber to meet our needs, until our forests have had time to grow again. But if we act vigorously and at once, we shall escape permanent timber scarcity."

CHEMICAL SECTION

(*Stated meeting held Thursday, February 4, 1909.*)

CALCIUM ALUMINATES; THEIR EFFECT ON MORTARS.

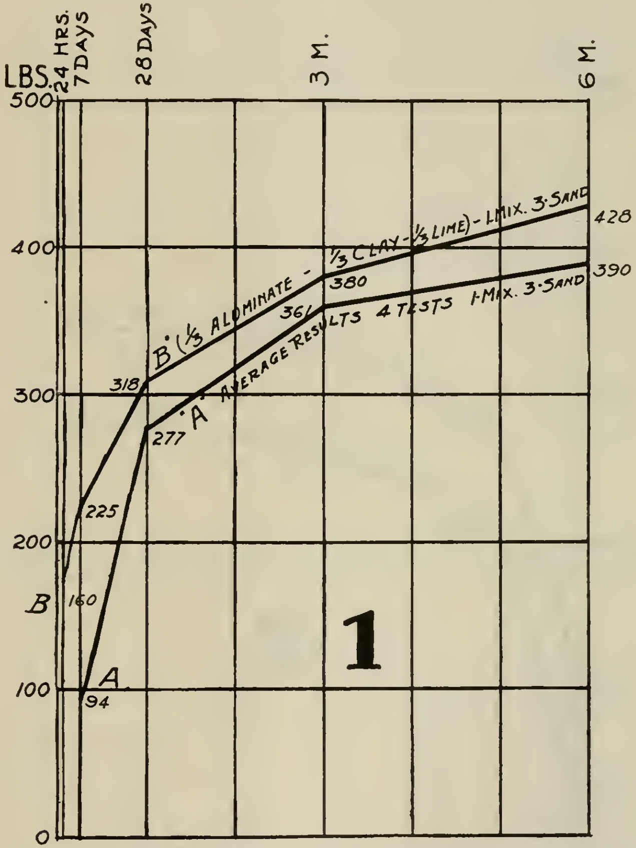
BY

HENRY S. SPACKMAN.

The effect of the addition of separately prepared calcium aluminate to the ordinary mortars used in the building trade has been carefully studied by the writer in the course of an extensive investigation covering the synthetic production of Portland or similar cements; that is, the method of making such cements by mechanically incorporating the ingredients without combining all the argillaceous and calcareous elements by calcination. This investigation grew out of striking results obtained some years ago in investigating the amount of material in Portland cement actually active in producing the hardening of the mortar.

When once undertaken, the scope of this investigation into the production of cement by synthetic methods broadened and became so involved that it has, up to the present time, included a vast amount of work, extending back over a number of years. For instance, the reactions of the single cement elements, such as lime and silica were studied under various physical and chemical conditions, and a large number of two-element compounds investigated, such as the calcium silicate and calcium aluminate series. Many striking incidental results were obtained but these are overshadowed by the industrial and theoretical importance of the demonstration by this work of the practicability of producing reliable cements by the incorporation of only a small percentage of accelerating or energizing material with mixtures of ordinary lime and shale, clay or other silicious material in finely divided condition.

We noted the effect of the addition of small quantities of calcium aluminate accelerator to mixtures of various proportions of hydrated lime and finely ground sand and of lime and ordinary field clay or shale which were used in their natural condition in which they possessed no hydraulic or cementitious qualities. Not only were the clay and shale alone devoid of binding properties,



Line A shows the average results obtained on a number of tests made with the California shale described in the detailed tests and covers variations in the amount of lime added and the percentage of aluminate, which varies from 7 to 12 per cent.; the lime varying from 29 to 45 per cent. of the mass. The tests given are the average breaking strength of the briquettes, mixed one part of the mixture of clay, lime, accelerator and retarder and three parts of standard sand, by weight. *Line B* shows graphically the tests obtained on a mixture of one-third shale, one-third hydrated lime and one-third aluminate. This mixture was mixed with three parts, by weight, of sand. The briquettes in each case were one day in air, balance of time in water.

but mixtures of these with lime gave no hydraulic qualities and only insignificant strengths, but with the addition of calcium aluminate decided hydraulic and cementitious qualities were developed in these previously practically inert mixtures. Practically any setting time desired could be secured by proportioning the amount of the accelerator and of retarding material, such as calcium sulphate, and so forth. The strength of mortar made with such mixtures can also be increased considerably

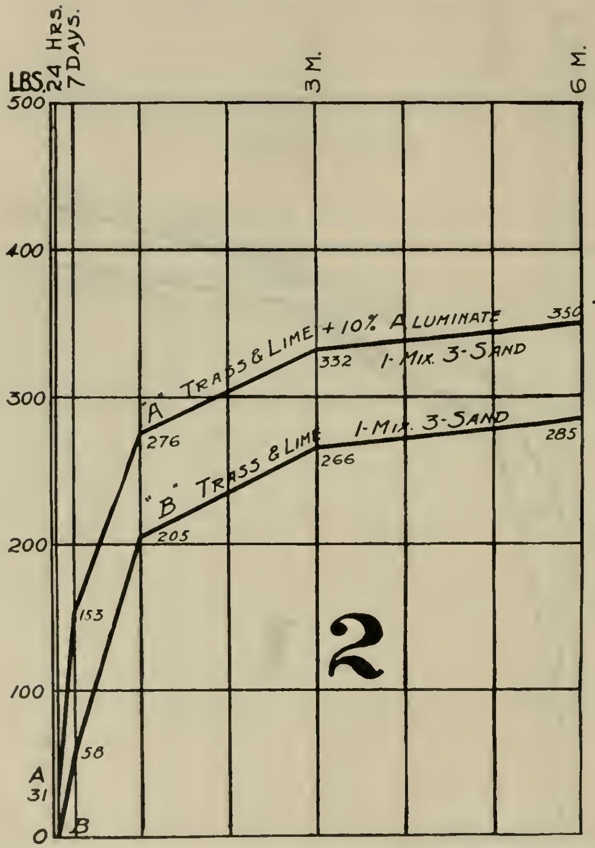


FIG. 2 shows the average results obtained on various tests of mixtures of trass, hydrated lime and calcium aluminates, the mixtures varying from thirty parts of lime to sixty parts of trass, to fifty parts of lime to fifty parts of trass, to which was added 10 per cent. calcium aluminate. The tests show the strength obtained from briquettes made from the above mixture to which were added three parts of standard sand, briquettes being one day in air, balance of time in water. *Line A* shows the average strength of the trass-lime mixtures to which aluminate has been added. *Line B* shows the average strength of the trass-lime mixtures without the addition of aluminate.

above Portland cement strengths at earlier periods by using more of the accelerator.

The experiments show that very valuable results were secured by using the accelerator with hydrated lime alone; the addition of small proportions of calcium aluminate to hydrated lime gave valuable wall-plaster compositions having quick hardening and increased spreading properties and very considerable strength in air at short periods, while larger proportions of accelerator gave strongly hydraulic compositions of greater strength. Incorporation of the accelerating material with trass-lime compositions gave striking results and natural cements are greatly improved in their early strengths, hardness, and resistance to abrasion by the use of a small percentage of the aluminate.

The aluminate compositions used in the investigation varied from those having approximately one-half molecule of lime to one molecule of the acid elements to mixtures having three molecules of lime to one molecule of the acid elements.

Tests were also made with aluminates prepared from bauxite and other materials, such as kaolin, high alumina slags, etc., all of which were found to work in a satisfactory manner, the presence of considerable amounts of iron and silica not being found objectionable. In the tests given below in order that they may be comparative, only those made with aluminate aproaching the monocalcic formula are given.

TESTS SHOWING THE EFFECT OF THE ADDITION OF CALCIUM ALUMINATE TO MIXTURES OF HYDRATED LIME AND ARGILLACEOUS OR SILICIOUS MATERIAL WITHOUT ANY TREATMENT OF THESE MATERIALS BEYOND PULVERIZATION.

ANALYSES.

Shale from California, Hydrated Lime, and Calcium Aluminate.

	Shale. Per cent.	Calcium aluminate. Per cent.	Hydrated lime. Per cent.
Silica (SiO_2) Al_2O_3	69.02	1.16	1.02
Alumina (Al_2O_3)	5.31	62.41	.42
Iron oxide (Fe_2O_3)	2.25	4.51	
Lime (CaO)	6.22	31.46	73.58 = 96.87 $Ca(OH)_2$
Magnesia (MgO)	3.12	.72	1.12
Loss on ignition	11.96	.02	23.66

The shale was exceedingly fine grained, no silica being present as sand. A mixture was made from these materials in the following proportions:

45 parts hydrated lime,
40 parts shale,
12 parts aluminate,
3 parts plaster of Paris.

This mixture when tested in the usual manner for physical properties gave the following results:

Tensile Tests.—One part mixture, 3 parts Ottawa sand; 1 day in air, balance of time in water. Setting time: initial set, 2 hours; final set, 4 hours.

48 hours.	7 days.	28 days.	3 months.
80 pounds	100 pounds	300 pounds	370 pounds
75 pounds	100 pounds	320 pounds	380 pounds
80 pounds	120 pounds	300 pounds	390 pounds
av. 78 pounds	106 pounds	307 pounds	380 pounds

Another mix was made from the above materials in the following proportions:

59 parts shale,
29 parts hydrated lime,
12 parts aluminate.

This mixture when tested for tensile strength in the usual manner gave the following results:

Tensile Test.—One part mixture, 3 parts Ottawa sand, 1 day in air, balance of time in water.

7 days.	28 days.	3 months.	6 months.
100 pounds	250 pounds	350 pounds	415 pounds
110 pounds	265 pounds	335 pounds	320 pounds
105 pounds	260 pounds	340 pounds	405 pounds
av. 105 pounds	259 pounds	342 pounds	390 pounds

Another mixture was made of the same materials in the proportions of:

⅓ shale,
⅓ hydrated lime,
⅓ aluminate.

This material when tested in the usual manner gave the following results

Setting time: initial, 35 minutes, final, 1 hour and 15 minutes. Soundness: air, O.K.; cold water, O.K.; steam, O.K.; boiling, O.K.

Tensile Tests.—One part mixture, 3 parts Ottawa sand, 1 day in air, balance of time in water.

24 hours.	7 days	28 days.	3 months.	6 months.
150 pounds	220 pounds	300 pounds	360 pounds	450 pounds
170 pounds	225 pounds	330 pounds	410 pounds	410 pounds
160 pounds	230 pounds	325 pounds	370 pounds	425 pounds
av. 160 pounds	225 pounds	318 pounds	380 pounds	428 pounds

Another test was made on the same materials using 7 parts aluminate, 45 parts lime, 45 parts clay and 3 parts plaster. This gave the following physical test:

Setting time: initial set, 2 hours; final set, 4 hours.

Tensile Tests.—One day in air, balance of time in water.

neat.	7 days.	1 cement, 3 sand
65		85
70		90
av. 68		av. 88

neat.	28 days.	1 cement, 3 sand.
225		320
245		350
av. 235		av. 335

(See Fig. 1 and legend, page 187.)

TEST OF CLAY FROM WISCONSIN HYDRATED LIME AND CALCIUM ALUMINATE.

	Clay. Per cent.	Aluminate. Per cent.	Hydrated lime. Per cent.
Silica (SiO_2)	68.84	1.16	1.02
Alumina (Al_2O_3)	12.07	62.41	.42
Iron oxide (Fe_2O_3)	7.17	4.51	
Lime (CaO)	1.16	31.46	73.58 = 96.87 $Ca(OH)_2$
Magnesia (MgO)	1.37	.72	1.12
Loss on ignition	9.54	.02	23.66

This was rather coarse-grained field clay containing some sand.

A mixture of the above materials was made in the following proportions:

35 parts clay,
55 parts hydrated lime,
7 parts aluminate,
3 parts plaster of Paris.

This material when tested in the usual manner gave the following results:

Setting time: initial, 1 hour and 30 minutes; final, 4 hours and 30 minutes.

Water Exposure.

7 days.	28 days.	3 months.
85 pounds	140 pounds	100 pounds
95 pounds	130 pounds	120 pounds
100 pounds	145 pounds	120 pounds
av. 93 pounds	138 pounds	113 pounds

Air Exposure.

1 cement, 3 sand.

7 days.	28 days.
100 pounds	100 pounds
130 pounds	110 pounds
115 pounds	110 pounds
av. 115 pounds	107 pounds

A mixture was then made from finely ground sandstone, hydrated lime, and calcium aluminate, analyzing as follows:

	Sandstone. Per cent.	Calcium aluminate. Per cent.	Hydrated lime. Per cent.
Silica (SiO_2)	90.26	1.15	1.02
Alumina (Al_2O_3) Iron oxide (Fe_2O_3)	3.82	62.41	.42
Lime (CaO)	.60	31.46	73.58 = 96.87 $Ca(OH)_2$
Magnesia (MgO)	.42	.72	1.12
Loss on ignition	.90	.02	23.66

The sandstone was ground to a fineness of 92 per cent. on No. 200 sieve.

These materials were mixed in the following proportions:

35 parts ground sand,
55 parts hydrated lime,
10 parts aluminate,

when treated in the usual manner gave the following physical tests:

Setting time: initial, 2 hours and 50 minutes; final, 8 hours.

Tensile Tests.—One part mixture, 3 parts Ottawa sand, 1 day in air, balance of time in water.

7 days.	28 days.	3 months.
75 pounds	50 pounds	100 pounds
70 pounds	60 pounds	120 pounds
75 pounds	50 pounds	120 pounds
av. 72 pounds	53 pounds	113 pounds

Tensile Test.—One part mixture, 3 parts Ottawa sand, air exposure.

7 days.	28 days.
95 pounds	160 pounds
110 pounds	150 pounds
100 pounds	150 pounds
av. 101 pounds	153 pounds

TESTS SHOWING EFFECT OF ADDITION OF CALCIUM ALUMINATE TO TRASS AND LIME MORTARS.

The materials used in the investigation were Trass from D. Servas & Sohne Koln a Rhein, Germany, high calcium hydrated lime and calcium aluminate made in the Laboratories of the Henry S. Spackman Engineering Co., Philadelphia, Pa.

These materials were found to contain:

	Trass. Per cent.		Hydrated lime. Per cent.
Silica (SiO_2)	55.62	Silica (SiO_2)	1.02
Alumina (Al_2O_3)	22.06	Alumina (Al_2O_3) Iron oxide (Fe_2O_3)	.42
Iron oxide (FeO)	1.64		
Lime (CaO)	1.82	Lime (CaO)	73.58 = 96.87 $Ca(OH)_2$
Magnesia (MgO)	.54		
Soda (Na_2O)	6.01	Magnesia (MgO)	1.12
Potash (K_2O)	1.71	Loss on ignition	23.66
Loss on ignition	10.16		

Calcium Aluminate.

Silica (SiO_2)	3.40 per cent.
Alumina (Al_2O_3)	45.16 per cent.
Iron oxide (Fe_2O_3)	12.80 per cent.
Lime (CaO)	35.40 per cent.
Magnesia (MgO)	2.72 per cent.
Loss on ignition	.64 per cent.

Mixture, 10 parts aluminate, 30 parts hydrated lime, 60 parts trass.

Tensile Test.—One part mixture, 3 parts standard Ottawa sand, 24 hours in air, balance of time in water, in pounds per square inch.

24 hours.	7 days.	28 days.	3 months.	6 months.
25 pounds	140 pounds	280 pounds	310 pounds	310 pounds
25 pounds	145 pounds	290 pounds	315 pounds	320 pounds
25 pounds	150 pounds	285 pounds	295 pounds	330 pounds
av. 25 pounds	145 pounds	285 pounds	307 pounds	320 pounds

Mixture, 10 parts aluminate, 45 parts hydrated lime, 45 parts trass.

Tensile Tests.—Twenty-four hours in air, balance of time in water in pounds per square inch.

Neat.

	24 hours.	7 days.	28 days.	3 months.	6 months.
	65 pounds	200 pounds	230 pounds	300 pounds	300 pounds
	75 pounds	200 pounds	250 pounds	320 pounds	310 pounds
av.	70 pounds	200 pounds	240 pounds	310 pounds	305 pounds

One Part Mixture to Three Parts Standard Sand.

	24 hours.	7 days.	28 days.	3 months.	6 months.
	55 pounds	205 pounds	310 pounds	380 pounds	380 pounds
	60 pounds	210 pounds	300 pounds	360 pounds	400 pounds
av.	58 pounds	208 pounds	305 pounds	370 pounds	390 pounds

TENSILE TEST OF TRASS AND LIME WITHOUT THE ADDITION OF ALUMINATE

Mixture, 1 part hydrated lime, 2 parts trass.

Tensile Tests.—One part mixture, 3 parts Standard Ottawa Sand.

24 hours.		7 days.	28 days.	3 months.	6 months.
no strength		60 pounds	210 pounds	250 pounds	280 pounds
no strength		60 pounds	200 pounds	280 pounds	285 pounds
no strength		50 pounds	205 pounds	270 pounds	290 pounds
	av.	58 pounds	205 pounds	266 pounds	285 pounds

(See Fig. 2 and legend, page 188.)

TESTS MADE TO SHOW THE EFFECT OF THE ADDITION OF CALCIUM ALUMINATE TO HYDRATED LIMES.

ANALYSES OF LIMES AND CALCIUM ALUMINATE.

	Calcium aluminate. Per cent.	High calcium lime. Per cent.	Magnesian lime. Per cent.
Silica (SiO_2)	9.14	2.77	2.30
Alumina and Iron Oxide (R_2O_3)	56.80	0.99	0.92
Lime (CaO)	31.32	70.67	43.34
Magnesia (MgO)	.80	1.38	29.46
Loss on ignition	2.08	24.10	24.14

The aluminate was mixed with the high calcium hydrate in proportion to 5 parts by weight aluminate, 93 parts hydrated lime and 2 parts plaster of Paris.

Tensile Test.—One part mix as above to 3 parts by weight Standard Ottawa Sand in pounds per square inch—air exposure.

	7 days.	28 days.	3 months.	9 months.	12 months.
	45 pounds	125 pounds	120 pounds	130 pounds	155 pounds
	50 pounds	130 pounds	120 pounds	130 pounds	180 pounds
	55 pounds	120 pounds	115 pounds	130 pounds	180 pounds
av.	50 pounds	125 pounds	118 pounds	130 pounds	172 pounds

The aluminate was mixed with high calcium hydrate as above in proportion 10 parts aluminate, 88 parts hydrated lime, 2 parts plaster of Paris.

Tensile Test.—One part mixture, 3 parts Standard Ottawa Sand in air, pounds per square inch.

7 days	28 days.	3 months.	9 months.	12 months.
85 pounds	170 pounds	150 pounds	120 pounds	200 pounds
90 pounds	150 pounds	185 pounds	135 pounds	175 pounds
70 pounds	145 pounds	120 pounds	120 pounds	170 pounds
av. 82 pounds	155 pounds	152 pounds	125 pounds	182 pounds

The aluminate was mixed with high magnesian hydrated lime as above in proportion by weight of 10 parts aluminate, 88 parts hydrated lime, 2 parts plaster of Paris.

Tensile Test.—One part mixture, 3 parts standard sand in air.

7 days.	28 days.	3 months.	9 months.	12 months.
70 pounds	155 pounds	155 pounds	120 pounds	165 pounds
65 pounds	130 pounds	165 pounds	125 pounds	190 pounds
70 pounds	120 pounds	170 pounds	115 pounds	210 pounds
av. 68 pounds	135 pounds	163 pounds	120 pounds	188 pounds

The aluminate was mixed with high magnesian hydrated lime in proportion by weight of 5 parts aluminate, 93 parts lime, 2 parts plaster of Paris.

Tensile Test.—One part mixture, 3 parts standard sand in air.

7 days.	28 days.	3 months.	9 months.	12 months
35 pounds	76 pounds	65 pounds	125 pounds	145 pounds
35 pounds	80 pounds	95 pounds	100 pounds	195 pounds
40 pounds	80 pounds	110 pounds	140 pounds	140 pounds
av. 37 pounds	78 pounds	90 pounds	122 pounds	170 pounds

Another test was made using an aluminate prepared after we had become more familiar with its manufacture, mixed in proportions of 10 parts aluminate, 88 parts high calcium hydrated lime, 2 parts plaster of Paris.

Tensile Test.—One part mixture, 3 parts standard Ottawa sand, in air.

48 hours.	7 days.	28 days.	3 months.	6 months.
49 pounds	94 pounds	96 pounds	120 pounds	130 pounds
61 pounds	118 pounds	94 pounds	130 pounds	135 pounds
63 pounds	91 pounds	92 pounds	125 pounds	145 pounds
av. 61 pounds	101 pounds	94 pounds	125 pounds	136 pounds

A test was then made using the last aluminate to determine the hydraulic properties. A mixture of 10 parts aluminate and 90 parts hydrated lime, gave when tested in the usual manner, 1 part mixture, 3 parts standard sand, 1 day in air, balance of time in water.

7 days.	28 days.	3 months.
5 pounds	30 pounds	50 pounds
5 pounds	35 pounds	60 pounds
5 pounds	40 pounds	50 pounds
av. 5 pounds	35 pounds	53 pounds

A mixture of 17 parts aluminate, 3 parts plaster of Paris, 80 parts hydrated lime.

Tensile Test.—One part mixture, 3 parts standard sand, 1 day in air, balance of time in water.

	7 days.	28 days.	3 months.
	65 pounds	120 pounds	100 pounds
	70 pounds	90 pounds	100 pounds
	50 pounds	105 pounds	130 pounds
av.	62 pounds	105 pounds	110 pounds

(See Fig. 3 and legend, page 197.)

TESTS MADE TO SHOW THE EFFECT OF ADDITION OF CALCIUM ALUMINATE TO NATURAL CEMENTS.

ANALYSES.

	Natural cement. Per cent.	Aluminate. Per cent.	Hydrated lime. Per cent.
Silica (SiO_2)	22.22	1.16	1.02
Alumina (Al_2O_3)	9.99	62.41	0.42
Iron oxide (Fe_2O_3)	2.63	4.51	
Lime (CaO)	54.72	31.46	73.58 = 96.87 $Ca(OH)_2$
Magnesia (MgO)	2.92	0.72	1.12
Loss on ignition	5.74	0.02	23.66

The natural cement was received in the form of clinker and to this was added 5 per cent of aluminate, 5 parts hydrated lime. The material was then ground and 2 parts plaster of Paris incorporated therewith. This material when tested according to the standard specifications for cement gave the following results:

Fineness: passing No. 100 sieve, 100 per cent.; passing No. 200 sieve, 91 per cent.; Setting time: initial set, 1 hour; final set, 1 hour and 30 minutes.

Tensile Test.—One part mixture, 3 parts standard Ottawa sand. In pounds per square inch, 1 day in air, balance of time in water.

	24 hours.	7 days.	28 days.	3 months.	6 months.
	205 pounds	350 pounds	450 pounds	495 pounds	470 pounds
	210 pounds	360 pounds	460 pounds	515 pounds	545 pounds
	195 pounds	360 pounds	460 pounds	550 pounds	495 pounds
av.	203 pounds	358 pounds	458 pounds	520 pounds	503 pounds

The cement was then mixed in the proportions of 80 parts clinker, 10 parts calcium aluminate, 10 parts hydrated lime, 2 parts plaster of Paris.

Tensile Test.—One part mixture, 3 parts standard Ottawa sand, in pounds per square inch, 1 day in air, balance of time in water.

	7 days.	28 days.	3 months.	6 months.
	375 pounds	500 pounds	515 pounds	595 pounds
	380 pounds	490 pounds	520 pounds	420 pounds
	370 pounds	510 pounds	545 pounds	640 pounds
av.	375 pounds	500 pounds	527 pounds	552 pounds

The above tests were then repeated on commercial samples of natural cement to which was added the calcium aluminate and lime, six different samples being tested. These were mixed in the proportions of 90 parts cement, 5 parts calcium aluminate, 5 parts lime. To this mixture 2 parts plaster of Paris was added. The average results obtained of this series of tests are as follows:

Fineness: passing No. 100 sieve, 99 per cent.; passing No. 200 sieve, 89 per cent.; Setting time: initial set, 1 hour and 14 minutes; final set, 2 hours and 9 minutes.

Tensile Test.—One part mixture, 3 parts standard Ottawa sand, in pounds per square inch, 1 day in air, balance of time in water.

Average of Fifteen Tests.

24 hours.	7 days.	28 days.	3 months.
A–145 pounds	222 pounds	304 pounds	463 pounds
B–141 pounds	217 pounds	312 pounds	404 pounds

The same cements were then tested with the addition of 10 parts aluminate, 10 parts hydrated lime, 2 parts of plaster of Paris being added. The average of these tests is as follows:

Fineness: passing No. 100 sieve, 99 per cent.; passing No. 200 sieve, 91 per cent.; Setting time: initial set, 54 minutes: final set, 1 hour and 40 minutes.

Tensile Test.—One part mixture, 3 parts standard Ottawa sand. In pounds per square inch. One day in air, balance of time in water.

Average of Six Tests.

24 hours.	7 days.	28 days.	3 months.
C–155 pounds	229 pounds	329 pounds	437 pounds

Average of Six Sand Tests Without Treatment.

24 hours.	7 days.	28 days.	3 months.
43 pounds	88 pounds	173 pounds	237 pounds

(See Fig. 4 and legend, page 199.)

In view of the fact that the investigation is still in progress, no specific conclusions have been drawn by the writer as to the exact manner in which the addition of the aluminate produces the striking results shown by the tests given.

The tests quoted, however, are typical and are borne out by the many other tests on similar materials made in the course of the extended investigations of the subject by the writer, but the fact that no explanation of how the aluminate acts is at present forthcoming is not a bar to the utilization of cement produced by this process. This is evinced by the fact that after many years of use and careful study the exact reactions taking place and compounds formed during the induration of Portland cement are still unknown. This is due to the fact that it is extremely difficult to isolate and identify hydraulic compounds which undergo decomposition or alteration on contact with water and to the fact that the crystals formed by the induration of cements are largely submicroscopic.

Considering the commercial applications and technical use of the results shown by the preceding tests, that is, the indication that the addition of a small percentage of calcium aluminate gives to materials possessing the property of hardening on being mixed with water, greatly increased strength, we will consider first the application of this discovery to limes.

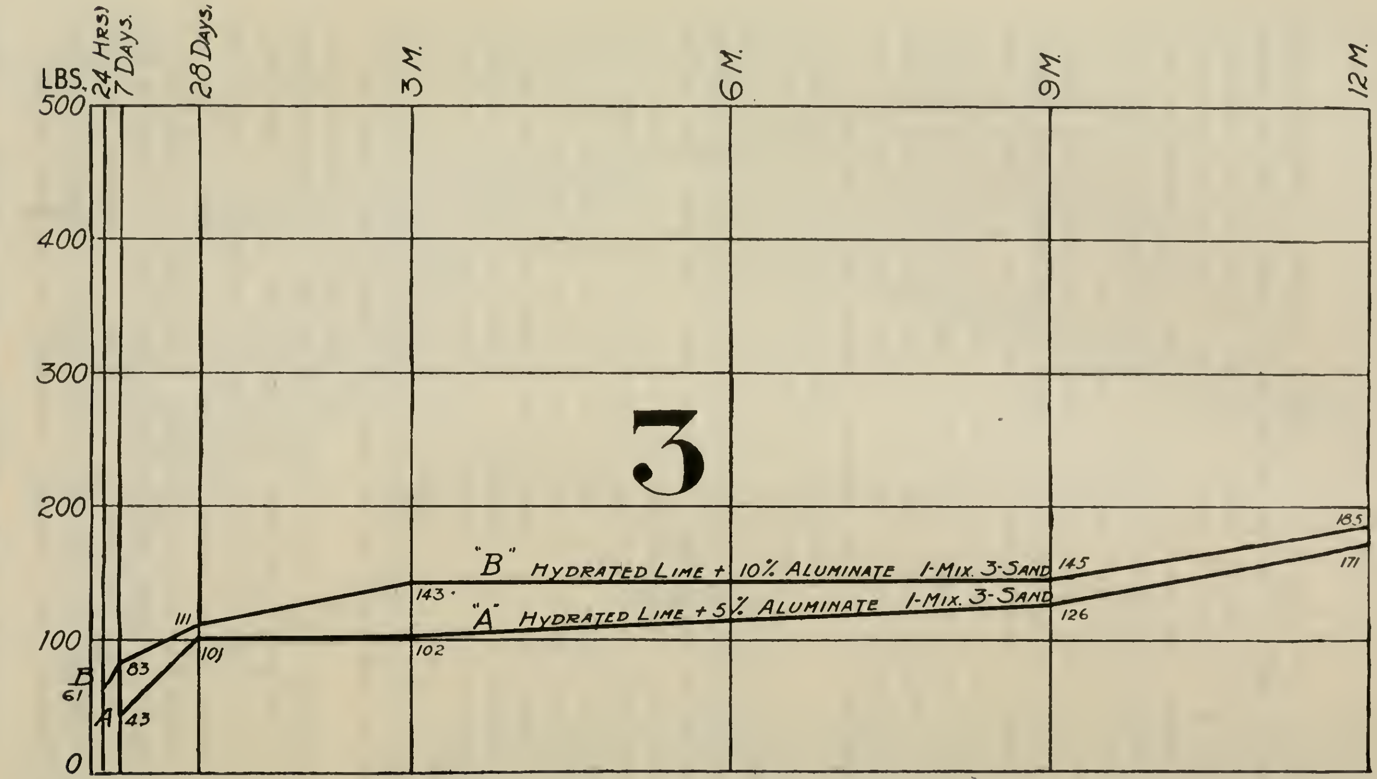


Fig. 3 shows the average strength obtained from a number of tests made on hydrated limes to which 5 and 10 per cent. aluminate has been added. Both high calcium and dolometic limes were tested and the results from these grouped together. *Line A* shows the tensile strength developed by hydrated limes to which 5 per cent. calcium aluminate was added, mixed one part mixture to three parts standard sand. *Line B* shows the strength developed by the same materials when 10 per cent. calcium aluminate was added, mixed one part mixture to three parts standard sand.

In ordinary building construction, lime is used for the laying of the foundation walls, brick work, and for plastering the interior surfaces of the building. Formerly the lime to be used for building purposes was brought to the building during the early stages of construction, slaked with water, and allowed to run off into large vats or beds where, stored in the presence of an excess of moisture, it became thoroughly hydrated. The lime-paste or putty so formed was mixed with sand and in this condition used for the laying of the walls of the building and their subsequent plastering.

In more recent years, in order to save the space occupied by the lime beds, especially in connection with urban construction, the lime is delivered to the building in a hydrated form as a dry powder. The use of hydrated lime is more common in Europe than in this country. Hydrated lime is produced by adding to the lime on slaking enough water to satisfy the chemical requirements of the lime and supply the loss by evaporation, with an allowance of two or three per cent. excess to provide for variation in the amount lost by evaporation. This reduces it to the form of a very finely divided powder, which may be mixed with sand and water and acts, in general, in, the same manner as the lime-putty prepared by the older methods; with the exception that by the process of dry hydration the lime seems to lose part of its plasticity and will not carry the same amount of sand or work as readily under the trowel.

According to the generally accepted theory, the strength of lime mortars depends on the cohesion of the crystalline compounds formed during setting and upon their adhesion to one another and to the particles of sand with which they are mixed. The first hardening is due to desiccation which, unless sufficient sand is added, is accompanied with considerable shrinkage in volume and consequent cracking. The lime in the mortar is present partly in a solid condition between the grains of sand as calcium hydrate and partly in solution. During drying, carbon dioxide is absorbed by this solution, forming crystalline calcium carbonate which under certain conditions may prevent the absorption of further quantities of carbon dioxide. Frequent instances are on record of lime mortar being found after a period of many years in the interior of heavy walls, in absolutely the same condition as when it was first used. This is

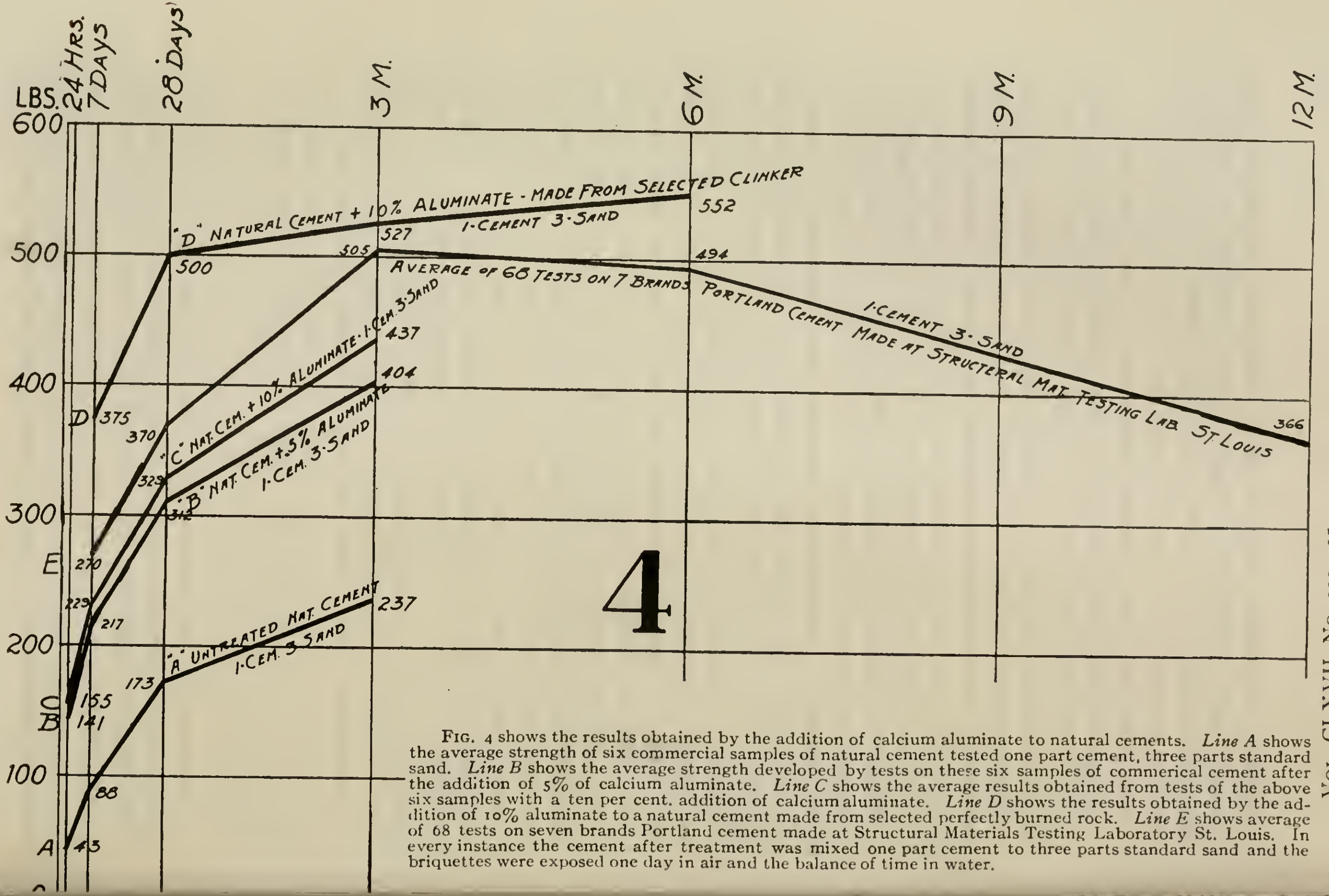


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FIG. 4 shows the results obtained by the addition of calcium aluminate to natural cements. *Line A* shows the average strength of six commercial samples of natural cement tested one part cement, three parts standard sand. *Line B* shows the average strength developed by tests on these six samples of commerical cement after the addition of 5% of calcium aluminate. *Line C* shows the average results obtained from tests of the above six samples with a ten per cent. addition of calcium aluminate. *Line D* shows the results obtained by the addition of 10% aluminate to a natural cement made from selected perfectly burned rock. *Line E* shows average of 68 tests on seven brands Portland cement made at Structural Materials Testing Laboratory St. Louis. In every instance the cement after treatment was mixed one part cement to three parts standard sand and the briquettes were exposed one day in air and the balance of time in water.

due to the formation of a crust or skin of crystallized calcium carbonate which prevents the access of air and the further absorption of carbon dioxide and also the drying of the mortars by evaporation. In a closed chamber, for instance, the absorption of carbon dioxide by fresh mortar soon ceases. The absorption of carbon dioxide is also dependent on the presence of moisture.

It will be seen from this brief description of the hardening of lime mortars that the strength attained by them is variable and governed by local conditions.

For plastering purposes lime has been largely supplanted by what are commonly known as " patent plasters "; these have for their base calcined gypsum and harden by crystallization. Pure plaster of Paris is, however, not available for work of this kind, owing to the interference of the rapidity of set with the smooth working of the mortars made from it. This is overcome by the addition of lime and retarders which may be either organic or inorganic. Such plasters are commonly supplied to the building in the form of a dry powder already mixed with the necessary amount of sand and hair required, other materials acting in the form of a stretcher are frequently present. These plasters harden with considerable rapidity and allow of the early completion of the buildings and do away with the necessity of slaking the lime on the work. They are, however, subject to several objections. It is claimed by their critics that they are lacking in durability and also are more expensive to apply owing to their low sand-carrying qualities and to the fact that the lack of plasticity prevents the mechanics from covering the same area of wall in the course of a day's labor. These plasters are also criticized for their tendency to warp and crack, the set taking placing before the lath has had time to expand after being moistened by the mortar. Yet in spite of these objections, owing to the slow hardening of lime plasters and the time and space required in their preparation by the old methods, the patent plasters have made great inroads into the trade of the lime burners.

The addition of a small percentage of calcium aluminate to hydrated lime as demonstrated by use in actual building work will give to this material all the advantages of a hard wall plaster without its objections and restore to hydrated limes the plasticity and sand-carrying power of limes slaked in the old way.

The set being more gradual allows of ample opportunity for any expansion of the wood work due to the moisture, while the hardening, which is reasonably quick, will continue with years and the plaster after acquiring its initial set is not damaged by water, but on the contrary its strength is increased. This makes lime treated by aluminates available for stuccoing buildings and other out-door work and prevents damage to plaster through leaking of the roof or plumbing.

These advantages will enable the lime burner to meet on a direct competitive basis the manufacturer of patent plasters.

Considering next the use of aluminated limes for mortars in the laying of stone and brick walls, etc., the addition of calcium aluminate, with or without clay ingredients, to hydrated limes will enable the lime burner to compete with the cement manufacturer in supplying mortar for such construction where the work is not below water.

While the making of cement by the addition of aluminate has not yet reached a commercial scale, experimental work done indicates that equally good results will be attained as with plasters. If this proves to be the case and it is shown beyond possibility of doubt that the addition of a small percentage of aluminate to natural cements or to mechanical mixtures of hydrated lime and Puzzuolanic material will produce a cement having the strength of Portland cement at earlier periods combined with the unquestioned durability and stability of the natural and Puzzuolanic cements, the effect on the cement industry will be revolutionary.

As you all probably know the past fifteen or twenty years have witnessed a phenomenal growth in the use and production of cement and a decided change in the character of cements used. Prior to 1892, natural or what was commercially known as Rosendale cements were used even in the most important engineering construction. In 1893 there was used in the U. S., 8,211,181 barrels of natural cement and 2,966,558 barrels of Portland cement of which only 547,440 barrels were of American production. From 1893 to 1900 the use of Portland cement rapidly increased, the U. S. Geological Survey reports for the latter year showing a consumption of 8,383,519 barrels of natural cement and 10,803,430 barrels of Portland cement of which 2,321,416 barrels were imported. In 1907, 51,000,000,000 barrels of Portland cement were used of which about 2,500,000 barrels were imported while the consumption of natural cement fell to 2,887,700 barrels compared with 9,868,000 barrels used in 1899. This lack of growth and falling off in the use of natural cement has been somewhat of a puzzle to thoughtful students of the subject. Popularly this decrease in the use of natural cement is accounted for by the impression or belief that natural cements are greatly inferior to Portland cements, both in strength and durability; this view, however, is only partly true and owes its origin to a comparison between tests made on Portland cements of to-day and those made on the natural cements produced by the crude methods that characterized the natural cement industry some years ago and which to some extent are still prevalent; yet these coarsely ground and carelessly combined and calcined cements proved equal to all strains imposed upon them by such structures as the first Brooklyn Bridge, the Croton Aqueduct, and other works of like magnitude.

It is perhaps well, for the sake of clearness, at this point to explain briefly the difference between Portland cement and natural cement in their character and action. As defined in the standard specifications, " Portland cement is a finely pulverized product resulting from the calcination to incipient fusion of an intimate mixture of properly proportioned argillaceous and calcareous materials and to which no addition greater than three per cent. has been made subsequent to calcination " while natural cement is defined as " a finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off carbonic acid gas." Both cements owe their cementitious properties to the same chemical components,—lime, silica, and alumina—and, as ordinarily made, differ chemically only in the ratio these components bear to each other. Broadly speaking, the Portland cements of commerce contain about two parts of lime to one of clay matter while in natural cement the ratio is about one to one, although the lime may approach that contained in Portland cement. It will be thus seen that the temperature of calcination is the most distinctive feature that differentiates Portland from natural cements.

Turning now to the difference noted in their use, the first point to be considered is the time of set, which, though part of the same phenomenon must not be confused with the ultimate

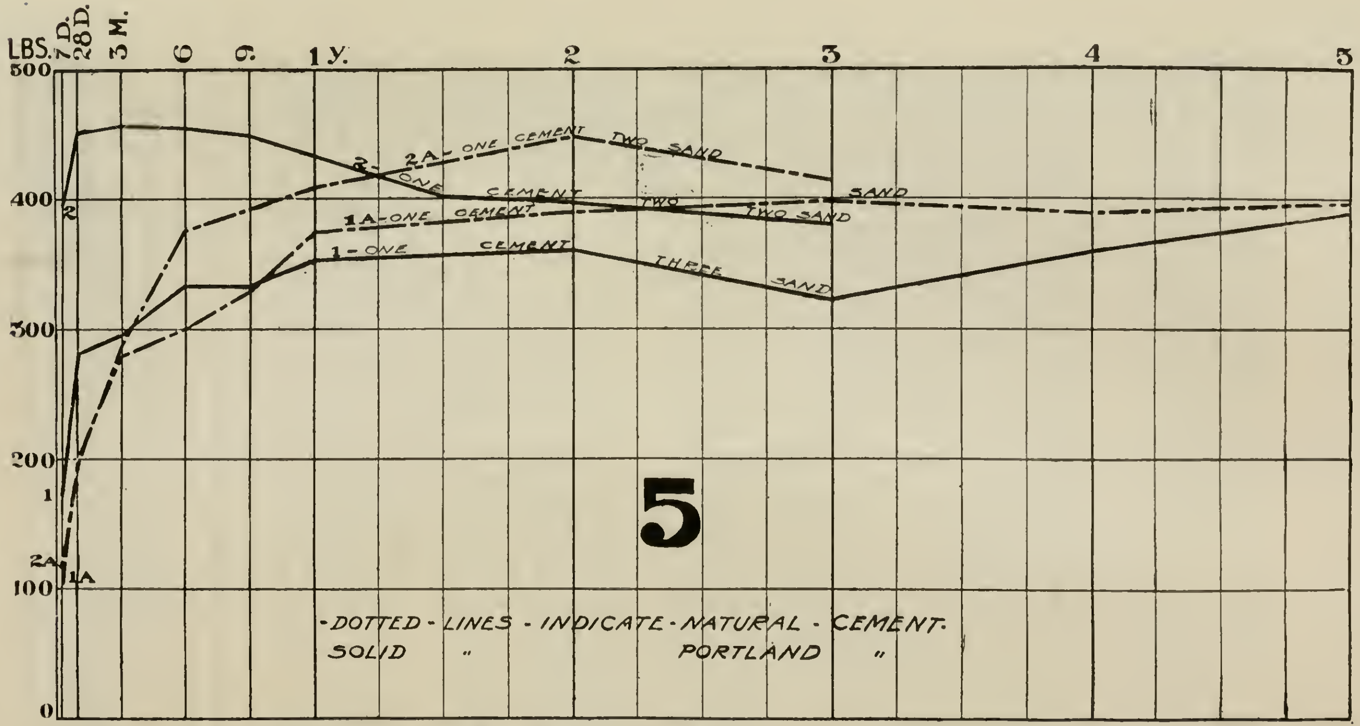

FIG. 5 shows a comparative long time test between natural and Portland cements. *Line* 1 shows the average strength of 14 brands of Portland cement. *Line* 1*A* shows the average strength developed by 9 samples of natural cement. The figures from which these curves are plotted were taken from the Report of the Operation of the Engineers Department of the District of Columbia for the year ending June 30, 1900 and the Portland cements used in these tests were made between 1885 and 1888 and were with possibly three exceptions, cements burned in the old fashioned set kilns. The average numbers six American cements and eight imported cements. *Line* 1 shows the average strength developed by a mixture of one part cement to three parts sand, one day in air, balance of time in water. *Line* 1*A* shows a mixture of one part cement to two parts sand, one day in air, balance of time in water. The data used in plotting lines 2 and 2*A* are taken from the Metropolitan Water and Sewage Board, Fifth Annual Report, January 1, 1906. *Line* 2 shows the average strength developed by eleven Portland cements mixed one part cement to two parts sand. These cements were probably all rotary kiln cements made between 1901 and 1903. *Line* 2*A* shows the strength developed by one brand of natural cement of which 182,480 bbls. were tested. This was mixed one part cement to two parts sand. All the briquettes were one day in air, balance of time in water. *Line* 2 shows the typical drop of Portland cement tested in tension referred to.

hardening or induration, but must be considered only as the time required for the cement to enter into solution sufficiently for the starting of crystallization and might be better termed "period of plasticity."

Most natural cements set in a few minutes, while Portland cements require one or more hours. This difference is not, however, inherent, the slow set of Portland cement being due to the addition of a retarder after calcination and the quick set of the natural cements would yield to the same treatment and it seems surprising that the manufacturers have not followed the example of the Portland cement manufacturers, as this quickness of set is objectionable and is one of the causes for the Portland cements superseding the natural cements.

The second and more important difference is the rapidity of induration. Portland cements, which are slow setting, harden very rapidly and at the seven-day period have, as a rule, acquired about 65 per cent. of their final tensile strength; the hardening continues more slowly until about the three-month period, after which there is, as a rule, no gain in strength, but a decrease when tested under tension.

Natural cements, on the contrary, are quick setting and slow hardening. At the seven-day period they rarely have over 25 per cent. of their ultimate strength and the increase is gradual and continuous to the six-month or year period. This condition is clearly shown by the accompanying diagrams.

It will thus be seen that the only superiority of Portland cement over natural cements is its slow setting qualities and rapid development of strength and if, as indicated by the tests read to you to-night and others made by the writer, a small addition of aluminate and retarding material will give to natural cements the slow-setting and quick-hardening properties resembling those of Portland, these cements may, by reason of their low cost and ease of manufacture and inexpensive works, regain not only the ground lost but compete seriously with Portland cement.

In conclusion, I wish to express my indebtedness to my former associate, Dr. E. W. Lazell, and to Mr. E. L. Conwell who personally performed all the work involved in the analyses and tests, for their assistance in this investigation.

SOME SUGGESTIONS FOR THE ADVANCEMENT OF THE PROFESSIONAL INTERESTS OF AMERICAN CHEMISTS.

BY
HENRY LEFFMANN,
Philadelphia.

THE large mass of literature now being produced annually on the subjects of sociology and economics indicates a period of serious unrest. The extent and intensity of the dissatisfaction with the methods of the distribution of the rewards for labor are probably greater than have ever been experienced. Changes more severe and more violent in organized government and social framework may have occurred in the past, but they have been limited in area, in the numbers of persons, and in the financial conditions involved. The present disturbance affects millions of people and millions of money, while the previous disturbances affected only thousands. Under the influence of the competitive system, backed by the results of inventive talent, scientific research, and a decline of true religious feeling, communities of even the most free and resourceful nations have been rapidly and ruthlessly divided into two classes,—the exploiters and the exploited, the bourgeoise and proletariat. In no case is this course of events more clearly and painfully evident than in this country. An immense area, rich in every material source of human comfort, lying undisturbed, except in a few places, until a century and a half ago, it has now an enormous population showing all the phases of misery and crime that attend overcrowding and underpayment. The abolition of a particular form of chattel-slavery has been followed by the extension of a system of wage-slavery that is no less degrading and disturbing. Natural resources, products of the land, such as water, timber, and minerals, have been everywhere taken under forms, or pretended forms, of law by a few individuals, to the deprivation of the many. The members of a liberal profession are probably much less liable to suffer from such misappropriation than the mass of those engaged in what are now technically known as "gainful occupations."

I have been asked by the management of the section work of the Institute to fill a space on the program for this meeting of the Chemistry Section, and it has occurred to me that it will be opportune to look about and see how the interests of practising chemists may be affected by the great economic evolution now taking place. Chemists can, indeed, scarcely be classed as a professional body in the strict sense of the term, for there is no definite organization governed by a code of ethics, and qualified to practise only after passing through a prescribed course of study. Even to-day, when so much is " regulated," any one may begin the practise of chemistry, and, so far as the *prima facie* status is concerned, rank with the best-trained worker.

Circumstances have saved chemists from the full incidence of the economic struggles that have borne down so many other wage-workers. One of these is the constantly increasing demand for chemists in connection with industrial development. It is easily within my memory when the employment of a chemist in connection with a manufacturing industry, a public service corporation, or a hospital was unknown and would have been regarded as a waste of money. I am quite familiar with the details of the original plans for establishing laboratories in connection with the Pennsylvania, Reading, and Baltimore & Ohio railroads. I made the first analyses for two of these corporations, consisting of examinations of the principal water stations along their lines, and I remember the efforts required to bring the general managers to see that systematic analysis in this and many other ways would be to the advantage of the corporations. The intense industrial struggle that began when the inventive talent of the country developed its force, compelled the resort to scientific methods and opened the field for the analyst so rapidly that for a time the demand exceeded the supply. The years of the fat kine are few, and the indications are that those of the lean kine have set in and are likely to be many. Several quite modern methods of operating are tending to place the chemist between the upper and nether millstone of the competitive system, and reduce him to the hopeless level of the specialized wage-worker. The colleges are doing a thriving business turning out bachelors and doctors of science and philosophy: the standarization of analytic processes is transforming laboratory work into a mere routine; the free supply of trained chemists is having its invariable effect on the compensation. Twice within a comparatively short period have I seen many righteous chemists forsaken. While business is booming, the industrial chemist profits somewhat, though not in proportion to his merit; but when the panic comes, he is thrown out without anything but a letter of recommendation.

Owing to the routine nature of many of the accepted analytic processes at the present day, much laboratory work requires but little ingenuity. The procedures are ordered with the formality of a cook-book or "Bob's Short Rules for Whist." For "one cupful of flour and a heaping teaspoonful of white sugar" read "50 c.c. of water and 5 c.c. of hydrochloric acid," and for "bake for twenty minutes in a quick oven" read "heat for half an hour at 100° with constant stirring," and we can see the relations between the cook and the chemist.

An editorial in the January number of *The Chemical Engineer* sets forth the conditions so vividly and authoritatively that I feel that I must quote freely from it. I deem it proper to say that the opinions expressed in this paper were formed before I saw this editorial, my attention having been called to it a few days ago by Mr. George C. Davis.

"All right-minded chemists who have had anything to do with general consulting work regret the tendency to commercialize analytical chemistry to the extent that the making of an analysis becomes as unprofessional a matter as the making of a chair or a cupboard. Many manufacturers are beginning to ask for bids on their analytical work, and are giving it as the result of these to the laboratory which will do it cheapest, without regard to the professional attainments of the man who is going to make the determinations. If this state of affairs continues, the profession of consulting analytic chemist will soon reach a point when our laboratories will be in charge of men with business heads rather than technical ability.

"The result of this tendency to commercialize analytical chemistry is beginning to make itself felt in a good many distressing ways. The following instance recently came to our attention. Two large foundries each employed a chemist. Both men were graduates of well-known technical schools with experience. A commercial laboratory was started in the neighborhood. This laboratory came to each of the plants with a proposition to make their determinations at a flat rate of fifty cents each, and finally, failing to get the work at this price, they lowered it to a figure which amounted to twenty-three cents (ominous figure—L.) for a silicon determination. At this quotation both foundries were induced to let their chemists go.

" The commercial laboratory had for its head a young man of considerable business push, a college degree, and one or two years' experience in the laboratory of a large steel works. He knew that a Hungarian boy could be taught to make twenty or thirty determinations of silicon a day if some one else did the weighing. He knew that a boy of slightly more intelligence could be taught to run as many volumetric sulphur determinations. Figuring the boys' wages at $7 per week, he found it an easy proposition to make a fair profit on silicons at twenty-three cents each. . . .

" We have known business men who employed the highest priced physician in the town, their chauffeurs were engaged at a salary almost princely compared with that of the average chemist; when they had need to dodge the law, the attorney was a man whose fees ran into three figures; yet these same men would sit down and write a letter to every laboratory advertising in the engineering magazines, asking for quotations on analytical work, and invariably sent what they wished to have done to the man who made them the lowest price. . . .

" It is not only the chemist of poor experience and doubtful professional integrity who is taking his services to the auction room. . . .

" We know of one large laboratory headed by a man of the highest professional type, which formerly had its testing in the hands of experienced chemists and engineers, whose staff has now degenerated into a force of beaker washers and sample takers few of whom would be able to pass the entrance requirements of a first-class high school."

What remedies are available against this state of affairs? The materialistic conception of history—that is, history as the record of a struggle for existence under biologic principles, and not as the manifestation of supreme power working out a scheme of sin and redemption—shows us that but two methods are of any effect. One is a complete absorption by the community of all competitive occupations; the other is combination of workers in any specialty to limit the number of qualified laborers and to compel by pains and penalties the observance of certain hours of labor and compensation, the latter called a wage-scale or a fee-bill according to the social position of the workers. One profession has from a remote period enforced to the utmost the second method. Lawyers maintain an absolute monopoly. No one can enter upon the practice of law in the courts of this Commonwealth, for instance, without undergoing examinations prescribed by the legal authorities. Even the entrance upon the study of law is stringently controlled, the required examination being more difficult than that exacted by the majority of professional schools. Moreover the professional privileges of members of the Bar are entirely in the keeping of that profession. For infringements upon its rules—that is, for being a "scab" workman—an attorney may be stricken from the list and thus wholly deprived of his means of livelihood. In the medical and dental professions infringements of the principles may be punished by exclusion or suspension from the societies, but the right to practise can be denied only by elaborate legal proceedings, to which the Bar as an organization lends no important aid, rather, indeed, interferes with it. Upon lawyers, as a class, the burden of professional life rests very lightly. They frame our laws and interpret them, and in the matter of fees and privileges they always know their own.

I do not think it will be safe for analysts to wait for the establishment of state control. It is necessary to turn to the other method. It is the object of this paper to advocate the plan that has of late been somewhat discussed elsewhere,—namely, to organize the practising analysts of the nation into a society for mutual protection. Such a society should carry on the same propaganda work that the medical, dental, and pharmaceutic societies are doing, especially secure legislation regulating the education of analysts and excluding all who do not conform to such requirements. Although the regulations concerning the three professions just mentioned are in this country, still unsatisfactory, yet much has been accomplished, and now no person can even enter upon the study of medicine or dentistry without complying with certain requirements, and the lines are being drawn stricter every year. Members of these professions sometimes take offence when such regulations are declared to be analogous to the efforts of day laborers against "open shop," but the difference is often nominal. For my part, I consider it no condemnation of the efforts at restriction of the practice of the professions to classify it as the same in principle as that of the closed shop. I justify entirely the efforts of the wage-workers in their struggles. Without such control they would be reduced to minimum wages and be in desperate straits.

It behooves practising chemists, therefore, to make a national organization, the object of which shall be to promote their interests as against the efforts of the capitalistic class to degrade the professional standing and to reduce compensation to the minimum. It may be said that a national society is already in existence. The American Chemical Society does not and will not fulfil such a protective function. The controlling influences are and long have been those whose withers are wholly unwrung by the struggles of the independent worker. The society's attitude in this respect has been clearly emphasized by the recent proposition to admit "corporation" members. I do not know whether this plan has as yet succeeded, nor is that important. It will soon succeed. The bait offered is that such members will pay twenty-five dollars as against the ten dollars that individual members pay. Inasmuch as the financial condition of the society is rather Micawberish, the majority of members will feel that, whatever sentimental objection may exist against such admission, the society needs the money. In the same manner a local organization formed to collect, in social and intellectual relations, a certain class of persons, now finds itself in some financial stress, and proposes that associate members shall be permitted to vote and hold office, not because such members will be of advantage in the scientific work of the society, but again because it needs the money.

With the entrance of corporation members into active relations in the American Chemical Society, the power of the independent chemist will be still further put into the background. No resolutions disapproving of the practice of asking bids for analytic work could prevail at a meeting at which corporate interests were thus represented. It must not be forgotten that the corporate members will be regularly represented at the meetings. Their object in accepting membership will be to have a representative to look after their interests and see that no sentimental action likely to diminish manufacturers' profits shall take place.

Holding that no present organization is sufficiently free from corporate control to be of use to the independent chemist, my advice is, as I have said, to form a new society. To give to such society a real ameliorating influence, it should be made up only of those who are directly interested. It should be based upon the principle applied in the formation of the British Society of Public Analysts. None but independent practising analysts should be eligible to membership. Teachers of chemistry in incorporated institutions, chemists wholly employed by corporations, chemists holding salaried positions under national, state, or municipal governments, should be excluded. All these persons are subject to a control, directly or indirectly, that would make them often lukewarm or even antagonistic to the interests of the independent workers. The professor of chemistry in a great university, recipient of a good salary and relying for any extra compensation upon consulting work brought by large corporations or public officers, feels no sympathy with the small fry who are doing odd jobs. I remember very well, in my own earlier experience as a general analyst, that a certain person then influential in Philadelphia scientific circles never recognized me as a chemist except when a subscription paper was being circulated. Then I was politely addressed as a fellow chemist and requested to send a check. Chemists connected with corporations under salary and those holding public office are not sufficient owners of themselves to be of much use in holding up a movement for independent standing in chemistry.

I hold, therefore, that the time has arrived for the independent analysts to form a society for mutual protection, this society to be national in scope with a thought of international affiliation. The name "American Institute of Chemistry" could be pre-empted now and would probably be satisfactory. As the burden of dues is now serious, the cost of membership should be as low as consistent with necessities. No attempt should be made to publish scientific proceedings or to expend money in social enjoyment, but the organization should devote its means to the uplifting of the professional character and to the prevention of the absolute commercialization of analysts.

Many will regard me as a calamity howler, and many others as offering a quack remedy. The recent effort within the American Chemical Society to form an Institute of Chemistry and the editorial in the *Chemical Engineer* from which I have quoted are evidences that something is rotten in the State of Chemistry, and that some counsel should be taken as to ways and means of eliminating the objectionable conditions.

TRANSPORTATION IN ALASKA.

Improved transportation facilities are admittedly among the most urgent needs of the mining industry in Alaska.

The field parties of the U. S. Geological Survey report that much progress was made during 1908 in the construction of roads and trails, but these can only supplement and can not supplant railways. The inadequacy of the river transportation lines in seasons of low water was strongly emphasized by the conditions that prevailed on the Yukon last summer.

The advancement of several railways, among which were the railways to the Matanuska coal fields and to the inland copper fields from both Valdez and Katalla, which had been actively pushed during 1907, was greatly retarded by the unfavorable financial conditions; but in gratifying contrast to the slow headway made by these enterprises was the rapid progress made by a railway being built up Copper River from Cordova. This line was completed to Childs Glacier in September. In connection with this road steamers are to be run from Abercrombie Rapids, so that during the coming year it will be possible to avoid the long overland journey from the coast to reach Chitina copper belt. As the railways in Alaska are of much public interest at present, the following table of mileage, compiled from the best available data, has been prepared for the Geological Survey's annual report on the mining industry in Alaska:

MILEAGE AND TERMINALS OF ALASKA RAILWAYS, DECEMBER 4, 1908.

	Miles.
Seward Peninsula:	
Seward Peninsula Ry., Nome to Shelton	80
Paystreak to Branch S. P. Ry.	6.5
Council City and Solomon River R. R., Council to Penelope Creek	32.5
Wild Goose Ry., Council to Ophir Creek	5
Fairbanks:	
Tanana Valley R. R., Fairbanks and Chena to Chatanika	46
Kenai Peninsula:	
Alaska Central R. R., Seward to near head of Turnagain Arm	53
Copper River:	
Copper River R. R., Cordova to Childs Glacier (Sept. 17)	47
(Probably 11 miles have been built since September 17. Same railroad at Katalla, where there has also been some work done by a rival company, has built between 3 and 4 miles. At Valdez a few miles of track of the Alaska Home Ry. were laid in 1907.)	
White Pass:	
White Pass and Yukon R. R., Skagway to White Pass	20.4
(Terminal at White Horse, Yukon Territory.)	
Yakutat Bay:	
Yakutat Southern Ry., Yaktutat to Situk River	9

Portions of the Council City and Solomon River and of the Alaska Central are out of repair and not in use.

NOVELTIES AS TO THE PREPARATION OF EXPLOSIVE CHARGES WITH A TRI-NITRO-TOLUOL BASE.

BY

M. R. ESCALES.*

Translated from the *Moniteur Scientifique* for August, 1908.

BY

W. J. WILLIAMS, F.I.C.

It has been known for twenty years that tri-nitro-phenol (picric acid), $C_6H_2(NO_2)_3OH$ has played a considerable part in the technic of military explosives, and that it is used in enormous quantities in Germany as a charge for projectiles (Granatfüllung 88 and Sprengmunition 88), in France under the name of mélinite, in Italy called pertite, in England as lyddite, and in Japan as shimose powder. Tri-nitro-phenol, however, acts inconveniently as an acid and combines with metals or basic substances. These compounds are very susceptible to shock,[1] they explode easily, and consequently, acting as an opposite to the rest of the charge which remains almost wholly intact, they become an important factor. Besides this, the fine dust of picric acid is noxious to health.

In a paper, published in this journal in the first part of last year, J. Rudeloff has shown that for the above reasons, tri-nitro-toluol, $C_6H_2(NO_2)_3CH_3$, has become of greater and greater importance and has become a serious competitor of picric acid. In this communication, with the patents before us, we propose to describe certain novelties which have been discovered by Mr. Christian Emil Bichel, the eminent savant and technician who directs the Carbonite (Explosive) Co. In the first German patents (D.R.P. 177738 of Sept. 5, 1905) Mr. Bichel indicates a means of reuniting several small charges of a tri-nitro-toluol explosive into one large one. For military purposes it is of great importance that an explosive can take any form (shape) that may be desired. However, tri-nitro-toluol is easily fused on a water- or steam-bath (its fusion point is 81° C. to 81.5° C., or lower) and can be poured without danger into a shell or any hollow body. Moreover, as the density of tri-nitro-toluol is only 1.54, it is necessary to compress the flux under a relatively high pressure. Compression enables us to get a very dense explosive, which is desirable; for it is important to get the greatest possible weight of explosive into the limited space which occurs in a projectile, a mine, or a torpedo. But the compression of large charges presents many technical difficulties from different points of view, on one hand there is the danger that the charge in the zone nearest to the firing pin should reach too great a density (which would be the greater as the charge was longer); on the other hand, the size of the charge is limited by the danger to the neighborhood from its explosion. In order to prepare heavy charges of uniform density without any danger of explosion, it is desirable first to compress several small charges, and then to reunite them into a single charge. While reuniting these small charges there is no danger of an explosion if a nonexplosive agglomerant is used. However, Bichel has discovered that fused tri-nitro-toluol itself makes an excellent agglomerant, when it is poured, in the fused condition, on a charge of tri-nitro-toluol heated to a temperature near to the fusing point. If one or both of the surfaces of charges which it is desired to reunite are coated with melted tri-nitro-toluol, on cooling a joint is formed which cannot be broken even by very strong traction. In this way a charge of the shape and size desired can be produced from small charges of uniform density by reuniting them with an agglomerant of a density differing but little from that of the joined charges, which has a certain explosive power and which propagates the detonation from one portion to the other very thoroughly. The density of fused tri-nitro-toluol is about 1.54, that of compressed tri-nitro-toluol may reach 1.74, but is considered practically as 1.65. As this density differs but little from that of fused tri-nitro-toluol, by this method is avoided the contraction of the charge when cooling, the friction which results in loading projectiles and the weak points which form the joints in such large charges as those in the points of torpedoes.

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* Zeit. für das Gesamte Schiess- und Sprengstoffwesen, 1908, p. 21.

[1] According to Will, picric acid explodes under the blow of a weight of 2 kilogrammes, falling from any height between 35 and 95 cm., according to the conditions (*i.e.,* whether the explosive has been previously dried or not, whether it is pulverulent or compressed, unprotected or wrapped in tinfoil, or whether a piston is, or is not, interposed). On the other hand, the picrates explode with a low fall—5 cm. is enough for lead picrate, 7 cm. for iron or copper picrates.

In the German patent, No. 181471, of November 4, 1905, Bichel indicates a novel method of protecting the explosive charges of tri-nitro-toluol (or other substances) from cracking and crumbling, by which means the charges become less sensitive to shock, and are more easily preserved. The system of wrapping them in cartridges, hitherto used, takes up too much space, and does not protect them from the shock to which the charge in the projectile is submitted at the moment of firing or when it reaches the target. Bichel covers the charge with a small bag of mixed, elastic tissue, either of animal or vegetable origin (silk, wool, or cotton) such as is usually made in the textile industry. The thickness of this knitted fabric can be varied at will. In its application, a band of this very elastic tissue is wrapped around the cartridge in such a way that it fits it well and can be well fastened. The ends may be folded over and pasted, or cut off. After the cartridge has been strengthened by its knitted envelope, it can be given its definite shape, and its resistance can be increased by painting with shellac or varnish or by dipping it in these materals. By using such an envelope, the resistance of the cartridge to the absorption of moisture is also increased.

However, tri-nitro-toluol alone is but little sensitive to shock, and moreover, cases may occur when it is desirable to increase this insensitiveness. According to the German patent, No. 181754, April 12, 1906, Bichel attains this result by adding naphthalene; to combine these two bodies, they should be fused together, or should be dissolved together, the solvent being afterwards removed by evaporation. They may also be mixed mechanically, afterwards applying pressure.

It is known that tri-nitro-toluol and naphthalene combine to form an "addition-product" in the proportion of one molecule of each; this compound can be mixed in all proportions with tri-nitro-toluol by fusion; and it is produced when tri-nitro-toluol and naphthalene are fused together in all proportions. The proportions in which these two bodies should be fused to attain the desired results are, however, limited on the one hand by the detonating power of the product, and on the other by the decrease of the explosive power. A convenient proportion, for example, is 5 per cent. of naphthalene to 95 per cent. of tri-nitro-toluol;

this compound shows a decrease in the percentage of the detonating power and the explosive power, as compared with those of tri-nitro-toluol, although the resistance to mechanical forces has been considerably increased. Thus, although tri-nitro-toluol can be exploded by the fall of a 20 kilogramme block through 5 cm., the above mixture can be exploded only by the fall of the same block through 15 c.m., the difference in the height of the fall is still more marked when a lighter block is used.

In the patents No. ·185957 and No. 185958, July 17, 1906, Bichel treats of the way of increasing the density of fused tri-nitro-toluol (or other fusible explosives) so as to attain, when possible the density of compressed tri-nitro-toluol. When fused at atmospheric pressure, picric acid has a density of 1.62, while tri-nitro-toluol is 1.54. If these two substances are poured into a closed vessel, previously warmed, and so arranged that either a vacuum can be produced therein or a pressure of several atmospheres reached, the density of the explosive can be increased in proportion to the pressure exercised. In order to withdraw the air from the fused explosive, it is necessary, first, to exhaust the closed vessel; this increases the density from 1.54 to 1.58 if the atmospheric pressure is restored before solidification; but if compressed air is applied the density rises still higher; for two atmospheres it becomes 1.6, if a pressure of three or four atmospheres be exerted it becomes 1.62. If the pressure is increased above four atmospheres, no appreciable increase of density is observed except for very heavy charges. This process is particularly efficient if the bubbles of air occluded in the fused charge are removed by producing a vacuum, before applying compressed air or any other inert gas.

Bichel attains a still higher density and at the same time a finely crystallized condition, by quickly cooling the charge while applying compressed air. Cooling is effected by placing the vessel in cold water, or any other convenient means; but it is nevertheless better to use a special apparatus. The arrangement is as follows: the fused explosive is poured into an appropriate mold or into the projectile which should be placed in an hermetically closed envelope. This envelope is connected directly to the air-blast and is placed either actually in cold water or surrounded by a jacket in such a way that a current of cold water can be forced to circulate in the annular space between the envelope and the jacket. The air-pipe enters the envelope which is hermetically closed on its upper surface. The envelope is fixed in threaded clamps. If desired, a battery of similar vessels can be used.

The use of tri-nitro-toluol is inconvenient in many cases; *e.g.*, if the projectile is not fitted with a (threaded) screwed base and the orifice at the ogival head is narrower than the interior space; it is impossible to introduce compressed tri-nitro-toluol without having blow-holes, and difficult with the simply fused material, while crystalline tri-nitro-toluol cannot be introduced without producing dust (powder). Bichel proposes to prepare tri-nitro-toluol for filling projectives in a plastic condition easy to form into a shape suitable for introduction and agglomeration under pressure.

According to the German patent, No. 193213, May 24, 1906, this result is attained by adding resins, either melted or in solution, to the tri-nitro-toluol, either pure or mixed with di-nitro-toluol; in this way, by the use of melted resins, for example, balsam of copaiba. crystalline tri-nitro-toluol can be transformed, with or without heating, into a plastic explosive, which detonates easily, and it can be easily worked in suitable mixers; or resins soluble in liquid hydrocarbons such as spirit of turpentine can be used. Liquid or solid resins, such as liquid storax or benzoin, can be mixed with so-called liquid di-nitro-toluol, and a mixture of this product with tri-nitro-toluol makes a plastic explosive. In any case, the plasticity can be increased, and made comparable to that of gelatine dynamite, by adding suitable quantities of collodion cotton. The resins and the di-nitro-toluol should be carefully purified and the collodion cotton can be added to the two substances, either before or after mixing them, provided the mixture is sufficiently heated when the additional collodion-cotton is introduced.

The resins and the di-nitro-toluol, are mixed with or without the collodion cotton, but at first without the tri-nitro-toluol for a long time while at the same time they are heated in an appropriate mixer, such as the Werner–Pfleiderer kneader, in such a way that they form a thick liquid; finally the tri-nitro-toluol is added; after which they are again mixed until they form a plastic mass easily molded. If the proportions are well chosen the product thus prepared should not adhere to the tools used for filling projectiles. cartridges. or torpedoes; it should be rammed down without any air-bubbles and consequently has a high density. As the tri-nitro-toluol constitutes the essential part of the mixture, the proportions should be so chosen that the explosive force is not much lower than that of pure tri-nitro-toluol.

Here follow types of the mixture:

I.	a.	b.
Tri-nitro-toluol	87	87
Balsam of copaiba	13	12
Collodion cotton	—	1
	100	100

II.	a.	b.
Tri-nitro-toluol	85	85
Spirits of turpentine (larch)	15	14
Collodion cotton	—	1
	100	100

III.	a.	b.	c.	d.
Tri-nitro-toluol	85	85	85	85
Liquid storax	5	4.5	—	—
Liquid di-nitro-toluol	10	10	10	10
Collodion cotton	—	0.5	—	0.5
Benzoin (gum)	—	—	5	4.5
	100	100	100	100

COASTAL PLAIN INVESTIGATIONS.

STUDY OF UNDERGROUND WATERS.

An investigation of the Atlantic and Gulf Coastal Plain of the United States, with special reference to the ground water of the region, is being made by the United States Geological Survey in co-operation with the State surveys of the various States interested. This work is under the control of a supervisory board composed of members of the National Survey and of the State geologists. Prof. William Bullock Clark, State geologist of Maryland, is chairman of the board, and T. Wayland Vaughan has general charge, on behalf of the National Survey, of all the investigations. Professor Clark is in immediate charge of the work in the Coastal Plain district from Massachusetts to North Carolina, inclusive, and has been engaged during the past year with his assistants in directing the work in New Jersey, Delaware, Maryland, and Virginia.

WORK IN VIRGINIA AND NORTH CAROLINA.

The Coastal Plain studies in Virginia and North Carolina have for the first time afforded a knowledge of the sequence of geologic formations of this part of the area and will be valuable in determining the horizons at which underground water occurs. In connection with the State geological surveys of Virginia and North Carolina, it is planned to issue at an early date special bulletins on the geology and water resources of the Coastal Plain regions in these States, and these bulletins will be followed later by special detailed reports or monographs on the stratigraphy and paleontology. These reports will afford information regarding the middle Atlantic Coastal Plain of Virginia and North Carolina that has not heretofore been available.

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GRAVITATION.*

BY
CHARLES MORRIS.

Of the many problems with which science has had to contend in the recent centuries, that concerning the origin of the force of gravitation has proved by far the most difficult to solve. There is no other problem in which some progress towards a definite solution has not been made, but the question of gravitation remains practically in the position which it attained more than two centuries ago, when Sir Isaac Newton discovered its law of operation and offered a suggestion as to its probable cause. Many other hypotheses regarding it have been propounded since his day, but none of them have proved more satisfactory than that of Newton himself, and to-day the problem of gravitation remains in the precise state in which he left it, namely, that attraction as a force inherent in matter cannot exist, and that the gravitative force is probably in some way due to the action of an ethereal medium in contact with matter.

All the theorists, since Dr. Hooke in 1671, have employed this conception, and though none of them have succeeded in attaining the desired result, the impression is general among physicists that the basis of their arguments is correct. If, indeed, we deny the possibility of attraction, of the exercise of force by a body upon some distant body, of "action at a distance," as it is termed; we are obliged to accept the only alternative, that all exercise of force must come through actual contact. And as there is no visible substance in contact with matter to which the force of gravitation can be ascribed, we are obliged to suppose the existence of an invisible one. And this must be an universal one, if, as is believed, gravitation is an universal force. Such an agent would probably resemble in some or all respects the hypothetical luminiferous ether.

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* In the "Journal" for February, 1906, the author published a paper on "The Problem of Gravitation," in which he made the phenomena of magnetic and electric attraction the basis of a hypothesis on this subject, drawing conclusions from these which seemed applicable to the gravitative force. He has since become convinced that his premises were incorrect and the result reached was erroneous. In the present hypothesis the phenomena of gravitation alone are considered.

There seems no escape from this conclusion. We are aware that matter exists in a state of compression, and that its masses and particles alike manifest a tendency to move towards each other. If we deny that this is due to the agency of an inherent attractive force, we must look elsewhere for an agent capable of producing the effect. Such an agent, it would appear, must be some force-exerting substance in contact with matter, such, for instance, as the luminiferous ether, the assumed conveyer of the waves of light and other vibratory impulses. To this ether, or to some ether better adapted to the purpose, all theorists have turned in their attempts to solve the mystery of gravitation. Yet if the luminiferous ether fills all space, as is claimed, it is highly improbable that there is a second ether coordinate with it. At all events it is unphilosophical to seek for such a second ether until it has been shown that the ether of whose existence we have some evidence from the radiant phenomena of nature has been proven incapable of performing the necessary functions. In place of conceiving of a special ether as the agent in gravitation, it seems more logical to credit the ether which science so widely accepts with properties in addition to those usually ascribed to it, yet in accordance with its nature, and seek to discover if any such conceivable properties may afford an explanation of the phenomena of gravitation.

This has been attempted without success by many physicists. Yet, as there is no evidence that nature possesses any other agent capable of producing the observed results, the impression is somewhat general that gravitation must be a result of some activity in the agent to which is attributed the conveyance of the rays of light. Of late years there has been a tendency to ascribe the gravitative effect to some involved or intricate mode of ether motion. Yet the probability of this we may justly doubt. This is not nature's method of action. Its great results are produced by simple and direct means. It thus appears logical to assume that this, the greatest and most general of all its processes, the one upon which the very existence of the material universe, as known to us, appears to depend, is the outcome of some such simple agency, not improbably the presence in the ether of some of the ordinary modes of motion which are visible or supposable in ordinary matter.

If we dismiss attraction as a force agency—as scientists very generally are disposed to do—we seem obliged to turn to the motion of some substance as the sole agent of force. At least the only agents suggested in all the years of scientific speculation on this subject have been attraction and motion. Each of these, acting from some substance, would be capable of exerting a compressive influence upon other substance, and we can conceive of no other agency competent to this effect. If attraction be dismissed motion alone remains, its force consisting in the momentum residing in some moving body.

Assuming then, in our study of gravitative phenomena, the necessary existence of an ether with properties adapting it to the purpose, the character of these properties comes next in question. The ether action can take only one of three forms; it must operate as a traction, a propulsion, or a pressure. Of these, traction—a drawing influence exerted upon matter by intermediate substance—has been avoided by theorists, none of them being able to suggest an effective mode of action of this kind. Propulsion—the force of impact—has been considered from various points of view, but ineffectively. Pressure has also been considered by theorists, with like unsatisfactory results. Yet from what we know of the phenomena in general, and of the progress of theory upon this subject, the latter seems the most probable and promising of the three methods.

Such is the status of the problem as it exists to-day, the foundation upon which any further study of the nature of gravitative force must be based. Newton's idea of the rarefaction of ether around masses of matter and a consequent pressure; Le Sage's conception of a second ether, consisting of swift moving corpuscles, acting through impact; Dr. Young's conception of the repulsion of ether by matter; and the many other hypotheses which have been propounded, have all been dismissed as inadequate, and all we have reached is the general proposition that gravitation is due to the action upon matter of some external energy, this presumably arising from some mode of motion in the luminiferous or other ether.

Before proceeding further two things must be considered: what modes of motion of a general or universal character are known to exist; and what do we know of the constitution and capabilities of the ether. In matter we are aware of only two general modes of motion, the direct motion of gaseous molecules, and the vibratory motion attributed to the molecules of solid material—the latter varying into curvilinear and circular motion. Ether, so far as hypothesis concerning it has gone, possesses but one mode of motion, the vibratory, the to-and-fro swing of its particles which is supposed to be the agency in light and other radiant manifestations. The assumption is that the ether particles are fixed in space and possess no direct motions, not darting about in the free and irregular manner attributed to gaseous molecules, but restricted to vibratory movements like those of the molecules of solid matter. Were the former the case, the motions which produce the phenomena of light would be dissipated and the transmission of light waves through space could not proceed. For this reason physicists hold that the ether must be similar to solid matter in its constitution or state of aggregation.

Of the other conditions of ether we know very little. It is regarded as a substance of extreme tenuity, and yet exceedingly rigid; as incompressible and yet highly elastic. Some maintain that it exists as a plenum, filling space to its full capacity, and yet possessed of a yielding capacity, so as to permit vibratory movements. Yet these suppositions seem to impose upon it irreconcilable conditions, and the fact that it admits of vibration renders it very probable that it possesses separate corpuscles, however minute, with space for them to move in, however contracted. That it is highly susceptible to movement we know from the freedom with which it responds to radiant impulses, and from this we may deduce the probability of its possessing movements native to itself, in addition to those impressed upon it by matter.

If ether be the seed stuff of matter, as is widely believed, it is reasonable to conclude that, as matter has absorbed only a minor portion of the substance of ether, so it has absorbed only a minor portion of its motions or activities. In such case it may possess active native motions and inherent energy of great intensity. Such would be necessary to make it the agent in the phenomena of gravitation.

If this be granted as probable, if ether does possess such a native mode of motion, of universal distribution, as contrasted with its partially distributed radiant motions, what is likely to be the character of this motion? The condition of the ether held to be requisite for the transmission of light, that is, the confined state of its particles, would appear to be preventive of any general movement through space, any power of direct transmission from place to place, and permit only some form of vibratory motion. And we may deduce from the fact that the molecules of each portion of matter vibrate at a fixed pitch, dependent upon their mass and condition, that the same is likely to be the case with the corpuscles of ether; since, in contrast to transitory vibrations, any native and persistent vibrations must be governed in rapidity by the constitution of the substance in which they exist.

Solid matter is capable of transmitting the vibrations of sound; but these, being at a pitch different from that normal to the molecules, are not absorbed by these. May not a similar condition exist in the ether? May not the radiant vibrations, at a great variety of pitch, impressed upon it by matter, similarly pass through it without absorption, while it has a persistent vibration of its own, at the pitch normal to its density? If the ether possesses any native motion at all, this is the form it must inevitably assume, supposing it to have the constitution usually attributed to it.

Let us assume the possibility of the existence of such an ether, filling all space not occupied by matter, capable of receiving vibratory impulses from matter and transmitting them intact to distant matter, and at the same time having vibratory motions native to itself and affecting its entire substance persistently. What deductions can we make from such a hypothesis? To be vibratory such an ether must be elastic. And if vibratory and elastic we cannot escape the conclusion that the corpuscles possess minute areas in which they move and to which they are confined. The density of such an ether would be due to its total quantity as compared with the area of space which it occupies in the universe. If its quantity be insufficient to fill this space absolutely there must be intervals, however minute, between its particles, and these would serve as areas of movement. The very rapid motion of the particles would enable them to keep these areas practically occupied and also would give rise to a homogeneous density throughout, except where the presence of matter might affect the density.

If we may assume these premises to be correct, the ether would be incompressible only in this partial sense, it being everywhere compressed to the limit of its elastic powers of resistance. Returning now to the question of vibration, how shall we comprehend the to-and-fro swing of particles of either matter or ether, if the seeming force of attraction be disregarded? If attraction is absent, what is there to hold the particles in restraint and prevent them from moving straight onward and escaping to new localities? To convert such a power of onward movement into a vibration there must be a controlling agency of some kind present. If it be not a power within the particle, it must be a condition without it. Can we imagine any such condition? It may be that we have one in the elastic resistance of the surrounding ether. Taking the case of a single vibrating corpuscle, we can readily conceive of its swinging into a nest of resisting ether, as fixed in place as itself, compressing this in doing so, and being driven back by its elastic expansion, to be similarly checked and driven back at the opposite extremity of its swing. Forced back with accelerating rapidity to the centre of its field, it would be again checked and brought to rest by a similar agency in its other phase of vibratory movement, the process being indefinitely repeated.

What becomes of the lost motion of the particle when thus brought momentarily to rest? We are not prepared to accept the ordinary explanation of potential energy, a hypothesis widely used in science to explain phenomena of this kind, but which is purely metaphysical and absolutely without demonstration. A more logical explanation would be that the lost motion of the corpuscle is taken up by the resisting ether, which in its elastic reaction yields reverse motion of its own to the vibrating corpuscle.

We cannot well avoid this conclusion. If we discard the idea of an inherent force of attraction in matter, and decline to accept the questionable potential energy, the only conceivable other source of the loss and gain of motive energy by the corpuscle must be the action of some external motive energy, which in this case might well be that of the elastic resistance of surrounding ether. Certainly it is not easy to imagine any other.

Leaving this phase of the subject and coming to the consideration of motion in its general aspects, the dictum of science is that all motion is normally persistent in force and direction. As no mass at rest can move of itself, so no mass in motion can lose or gain speed or change in direction of itself. Such changes can arise only from the action of external agents, and every change produced by these agents is compensated by an equal opposite change in themselves. Thus in the case of atmospheric molecules, which come into contact with each other thousands of millions of times every second, the motion of each molecule being incessantly diverted, the separate lines of motion, and the energy displayed in each, are never lost. They are simply transferred to other molecules, and pass unceasingly onward through space, being conveyed by myriads of molecules with the same effect as if they were conveyed by a single one.

This principle applies not only to free-moving particles, but to vibrating ones as well. We cannot imagine that the energy of the vibration is annihilated when the particle comes to rest at the extremity of its swing and new energy created when it returns. Nor can we logically imagine that the motion is temporarily changed into some condition of non-motion, as the hypothesis of potential energy demands. We therefore seem obliged to accept some such hypothesis of external influence as that suggested above, in which a compressible resisting substance takes up the lost motion, and by its elastic rebound imparts a reverse motion to the vibrating particle. In the case of vibrating ether corpuscles the surrounding ether may well be competent to perform this function. In the case of material molecules the surrounding ether may possibly perform the same function, the surrounding matter, presumably not in contact with them, being incapable of such an elastic function. In such a case the ether would act as the agent of a force analogous to that of gravitation so far as the particles of both matter and ether were concerned.

In fact, within the hypothesis here presented, if carried to its ultimate, may perhaps lie the solution of the whole problem of gravitation. This is the subject which we have next to consider. The motion of the vibrating ether corpuscle, when transferred to others, cannot vanish or lose any of its energy.

It must pass onward by interminable transfers from particle to particle. Thus we may consider space as being incessantly traversed by lines of motive energy, passing in every direction, unaccompanied by transfers of material, yet persistent in force and direction. In this transfer of energy matter and ether might both take part, though the ether, by virtue of its vastly greater space occupancy, would be the principal agent. It is adapted to this function by being highly susceptible to motive influences, and probably, like matter, normally in incessant motion.

The vibratory activity of the ether, thus formulated, would, as just stated, be far more than a local vibration. It would constitute a wave motion incessantly traversing space, analogous to the waves of light vibration, but differing from the latter in being longitudinal instead of transverse. Each vibrating corpuscle would cause a condensation of the ether into which it moved, this being followed by a rarefaction as it was elastically driven backwards, the energy embraced in its every swing being taken up by the resisting corpuscles, and in turn transferred by them to new corpuscles, thus passing indefinitely onward. There would thus arise a condensational-rarefactional wave like that of sound, differing from the latter principally in its agent and its vastly greater rapidity.

These lines of energy would not necessarily be confined to the ether, but might also traverse the particles of matter which they encountered in their course, their speed diminishing to correspond with the mass of these particles but their momentum remaining the same. And here the significant fact presents itself that wave motions of this type are of a kind adapting them to traverse matter in all its states, solid, liquid and gaseous alike, with equal facility, and ether also in all the states it is likely to assume. While transverse undulations, like those of light and radiant heat, are restricted to substance in the solid state of aggregation, longitudinal undulations have no such restriction, but are fitted to all known conditions of substance.

In a glance back at what has thus far been stated, it is apparent that this hypothesis adds nothing to the characteristics of ether assumed or conjectured to exist except the suggestion that, in addition to its radiant waves, it is in a state of incessant vibration, at a rate normal to its constitution, this yielding a system of longitudinal waves which in their out-flow may be capable of traversing ether and matter alike. There is nothing revolutionary in this suggestion. If the ether possesses any native motion at all, as is highly probable, this is the form it is most likely to assume, a mode of motion distinct from that of its radiant waves and therefore not likely to interfere with the latter. Yet in the incessant and universal transfer of energy through space which this hypothesis suggests nature may possess an agency of remarkable power and efficiency. On ether itself this transfer of force would, with its compressive action, produce an effect resembling that of gravitation. On matter it may perhaps serve as the agent in all the phenomena of gravitation.

The material spheres, which, at vast distances asunder, are distributed like floating islands in the ocean of ether, are likely to be acted on by its energies, whatever form these may take. We perceive them affecting ether by their motions and producing in it a great variety of radiant waves. May not the ether in turn affect these spheres of matter by its normal motions and produce some equally marked effect upon them? Permeated as they are by the ether, which acts upon their every atom and every electron, we may justly suppose that there will be varied phenomena of action and reaction between these diverse forms of energy-containing substance. Some of these phenomena are apparent to us in the rays of light and heat, which arise from the energies of matter. It is very probable that there may be others, as yet unknown to us, arising from the energies of ether. It is with the latter that we are here concerned.

Returning to the form of universally transmitted energy which we have above attributed to the ether, it is in order to consider what effect it is likely to produce upon matter. If this energy were met by an equal resisting energy in matter, an exact balance of force would exist between the two types of substance. If unequal in energy, as is most probable, the stronger would exercise some degree of control over the weaker. If the ether energies were the stronger, the resulting conditions might well be those of gravitation. In such a case the great body of ether surrounding and permeating every sphere of matter, and acting upon it with the full vigor of its native energies, might produce a compressive effect upon the sphere as a whole and upon its every part, and if the ether energy were sufficiently superior in force might bring about the spheral condensation which we perceive. We are not dealing here with any form of impact of moving ether, but with the force of transmitted vibrations of stationary ether, impinging incessantly upon the bodies of matter, and exerting a compressive influence upon them.

Let us consider any such body of matter acted upon on all sides and through all its substance by lines of force emanating from the boundless sea of ether, through the agency of the ether corpuscles in immediate contact with the material particles. This surrounding ether, if superior in energy to the matter acted upon, must exert a compressive effect, which we may here view in the separate cases of the three forms of matter. The resisting energy would be that of the molecular movements of matter, and if these be reduced by loss of heat the molecules might be pressed together so energetically as to cause them to enter the solid state. If, on the contrary, the heat energy of the molecules be increased the opposite effect would appear, they growing forcible enough to overcome in part the ether forces and break loose from their vibratory subjection into the freer mode of motion of the liquid. Still greater heat might enable the material to expand against the compressing force until it assumed the freedom of the gaseous state. Yet as the expansion of the gas would subject it to the compressive action of a much wider volume of ether, its molecules would still be held in partial captivity, and would need a much greater energy of motion to enable them to escape into cosmic space.

We are here brought back to our original premise, that if the compression of matter is not due to internal attraction, it must be due to external pressure. We have credited the ether with native energies under conditions that enable them to act incessantly upon matter, with the probability that they would exert the requisite compressive force. But there are other phenomena in gravitation than that of mere condensation, and no hypothesis can be regarded as tenable until it has been put to the test of explaining all the phenomena. To deal with these we must begin by taking the case of some single sphere, such as the sun, and seeing what probable effect such lines of ether energy would produce in it, beyond that of mere consolidation.

We know that the sun is a very porous body, containing far wider areas of space than of matter, its particles being very minute as compared with the space surrounding them, and are satisfied that it is everywhere permeated by the rare ether, which comes into contact with its every particle and is in position to act upon every portion of its substance. As a result there seems likely to be a continual action and reaction between them, an unceasing conflict between their respective energies. If, now, as premised, the energies of the ether be superior in force, the particles of matter will be driven together until their aggregated energy enables them to prevent further condensation. Part of the ether energy would be employed in maintaining this state of compression, part of it would be taken up by the molecules and be transferred by them to the ether beyond, enabling it to act upon more interior molecules. Thus the ether would lose energy only to the extent that it exerted a moving or controlling force upon the particles with which it came in contact, its surplus energy passing forward through the intermediate matter to the ether beyond, to be there again employed. The compressing force must be continually exerted, since any diminution in it would be attended by an immediate expansion in the molecular groups, and any cessation by an explosive outflow of the molecules. Hence a continuous re-enforcement from external sources of the ether energy would be necessary and this re-enforcement would be constantly supplied.

The conclusion to which this line of argument leads is the following: The loss of energy by the ether through its action upon matter would by no means be total. A portion of it would be absorbed by the matter acted upon, while the remainder would be transmitted by aid of vibrations of the material particles to the ether beyond, much of the ether energy in this way traversing the solar mass. As a final result, the lines of force which penetrated the sun and emerged upon its opposite side would have lost much of their energy and be weakened to the full extent of the work they had performed, becoming much less effective than the fresh volumes of ether energy flowing in from space upon the opposite side of the sphere. As they have been engaged in producing and maintaining the condensation of the solar substance, they have decreased in energy accordingly.

If the probable existence of such a state of affairs be admitted, it leads to conclusions of the highest importance. At every point on the sun's surface there would be an inflow of ether energy in full force, and an outflow of similar energy reduced in force to the extent of the internal work performed, the difference between these two sums of energy constituting the effective gravitative force at that point. Everywhere within the interior the same principle would apply, every internal molecule being differently affected upon its two sides, except those at the centre, where the inflowing volumes of gravitative force would become equalized. Everywhere else they would be impelled towards the centre. We would have here an effective mechanism, and one producing no heating effect upon matter, as in the case of the impacting corpuscles of the Le Sage hypothesis, since only that portion of the energy is absorbed which is necessary to maintain the gravitative compression.

The loss of ether energy here demanded would be analogous to the loss of heat energy by matter when it performs work, so that we may speak of the difference in condition between the inflowing and outflowing lines of ether force as practically a difference in temperature. But the point which it is especially desired to make here is that the decrease in energy of the outflowing ether must persist in the ether waves, or lines of vibration, as they flow swiftly outward through space, and may continue unchanged not only throughout the solar system but to indefinite distances beyond. As a result the sun would be surrounded by an ether atmosphere traversed in every direction by rays of vibratory energy of which those flowing inward toward the sun would be far more energetic than those flowing outward from it.

It is in this ether atmosphere that the earth and all the planets swim. In consequence, the inflowing ether energy would act upon them much more vigorously than the outflowing, the difference in propelling force being sufficient to give each of their molecules a slight set inward toward the sun, or, collectively, to impel the planetary mass as a whole in this direction, the agency affecting the planets being thus similar to that affecting the solar molecules. On the other hand, each planet would act similarly upon the ether and react upon the sun in the same manner, every cosmic body having an ether atmosphere of this kind effective upon other bodies in accordance with its mass and distance. At every greater distance from the sun or planet, the volume of its weakened ether would occupy a greater spherical area, increasing, as could be geometrically demonstrated, in the proportion of the square of distance, the gravitative effect therefore weakening in exact conformity with the Newtonian law of gravitation. In this hypothesis, as will be perceived, we are not dealing with a shadowing of one sphere from ether impact by another, as in the Le Sage hypothesis, but with a permanent condition of the ether surrounding each sphere and affecting every mass of matter within its influence with a force dependent upon its distance.

The hypothesis here presented has a special significance, as it offers a solution of the most difficult problem in the phenomena of gravitation, one which no previous theory has even attempted to explain. This is that of the instaneous transmission of gravitative force, its apparent passage over enormous distances in infinitesimal periods of time. Under the present hypothesis this abstruse problem vanishes. There is no transmission of force to be dealt with. If the ether is permanently affected around every cosmic body, each mass at any distance from it must at every instant be subject to the gravitative force suitable to that distance, and in any change of distance feel a similar instantaneous effect as it entered a new region of the spheral atmosphere.

There is another important problem in the relations of ether and matter that must be here considered, that of the movement of the spheres through the ether without evident obstruction. The theory that the ether exists in the solid state adds to the difficulty of this problem. It is gravely attempted to be explained on the basis of the fact that a weight will pass through a jelly without leaving any trace of its passage. The ether is compared to a jelly of extreme thinness. But as no weight can sink through a jelly without obstruction and loss of speed, the parallel does not hold good, or would not unless the ether was of infinite thinness, a condition which we cannot predicate of any cosmic substance.

Under the present hypothesis, however, this problem assumes a different aspect. The ether is not passive in its action. It exerts a force on the moving earth which might be highly obstructive to movement but for the fact that it acts with equal energy on every part of the surface, the lines of ether energy being as effective on the receding as on the advancing side of the earth in its orbital movement. Any increased pressure of the ether due to the earth's forward movement would be balanced by an equal increased reaction of the earth. And any decreased ether pressure on the receding side would be similarly balanced by a like decreased reaction of the earthly material. Thus it would appear that the variations in earth and ether action would be in exact balance and a moving sphere bear the same relation to the ether as a sphere at rest.

In conclusion it may be said that, under the terms of this hypothesis, the force of gravitation is only a portion, possibly a small portion, of the total energy of the ether, it being simply the difference in energy between the lines of ether energy that have been partly exhausted within a sphere and those of external ether. If we take the example of the molecules of the atmosphere, we would have the effect upon them of opposite lines of force: one series weakened by passing through the sphere, the other series in full strength; one pressing upward weakly, the other pressing downward strongly. The result would be the difference in energy between these two forces. The difference will increase the larger the sphere and the greater the internal work done. Thus, though the inflowing ether pressure on the sun would be the same as on the earth, the gravitative pressure would be much greater, on account of the greater enfeeblement of the ether that had traversed the sun. In open space the condensation of the ether is probably uniform, a fixed balance existing between the energies of compression and expansion. This balance may be disturbed by contact with matter, since there is reason to believe that the ether grows more dense in the interior of transparent bodies, where it meets with a diminished resistance. The ether which has penetrated a sphere would also probably be denser, from its fall in temperature or loss of energy and its consequent diminished power of resistance.

It may be desirable, in concluding this paper, to state briefly what results have been reached in preceding gravitation hypotheses. It is interesting to note that all of these are based on some action of an ether supposed to pervade space, and in nearly all cases they confine themselves to the energy effect of this substance on the spheres considered as wholes. Two only of them are based upon a special ether, separate from the ordinarily accepted ether. Sir William Thomson (Lord Kelvin) suggests that the phenomena of gravitation might be explained by the action of an incompressible fluid filling all space, created constantly in each particle and flowing off into infinity, or created at infinite distances and flowing in all directions in upon each particle. This idea of incessant new creation is too remote from scientific conceptions to be for a moment considered. The other hypothesis is that of the ultramundane corpuscles of Le Sage, interesting from the fact that it alone among gravitation hypotheses gained wide acceptance, and still finds adherents.

The Le Sage corpuscles consist in a vast number of minute particles moving rapidly in all directions, impinging upon every mass of matter and condensing it by the force of their impact. Where two spheres are sufficiently near each other, each "shadows" the other, that is, screens the other from a certain number of the corpuscles. There are thus fewer blows on their opposed faces than on their more distant faces, and this excess of impacts on their distant sides acts to force them towards each other.

This hypothesis has the advantage of dealing with molecules and atoms as well as with spheres, its swift-flying corpuscles being supposed to penetrate the spheres to their inmost recesses. Its simplicity and conceivable adequacy, as compared with other hypotheses, has rendered it attractive, even to many scientists. Yet it has been rejected by the great body of physicists for several reasons. Its requirement of a second ether, pervading a universe supposed to be already fully occupied by an ether of different character, is exceedingly improbable. And Clerk-Maxwell has demonstrated that the energy exerted by these corpuscles would far surpass that needed for gravitative purposes and, converted into heat, would be sufficient to raise the spheres to a melting temperature in a brief period. As regards the problem of the instantaneous transmission of gravitative force, it does not deal with it at all.

These points are dwelt upon here from the fact that the present hypothesis, while radically different from that of Le Sage, is like it in dealing with an ether that penetrates the spheres and acts upon every molecule of matter, and also formulates a condition somewhat like that of the "shadowing" of neighboring spheres by each other. It, however, deals with these subjects from a different point of view. Instead of presenting a flying corpuscle, striking the molecule with its full energy, and likely to yield far more force than is needed for gravitative purposes, it replaces impact by vibratory pressure in which only the energy needed is employed, all excess of energy being taken up by the molecules as vibration and passed onward to the ether beyond. Thus it does away with the necessity of a special ether, adapted to this function alone, and disposes of the difficulty of a surplus energy, while the "shadowing" action is replaced by a more effective mechanism. It farther is in accordance with the phenomenon of the instantaneous transmission over great distances of the gravitative effect. This is a crucial element in the problem. Instead of dealing with a simple action between sun and planet, it seeks to make this principle universal by showing that each sphere or mass of matter is surrounded by an atmosphere of weakened ether energy, decreasing in effect outwardly in strict accordance with the Newtonian law of gravitation. In this atmosphere all external spheres swim, so that their gravitation toward the acting body at each instant must exactly accord with their distance and vary in accordance with every change in distance, the time element being thus removed. There are other conditions, of a less stringent nature than this, demanded of all attempted explanations of gravitation, but these it is not necessary to name here, as none of them are violated by the present hypothesis.

[SUPPLEMENTARY NOTE.—Since reading the proofs of the above my attention has been called to an article by O. Keller, in Comptes Rendus, vol. 147, pages 853–856 (Nov. 9, 1908), on the Reaction of the Ether on Matter as a Cause of Universal Attraction in which the author shows that if the primary atoms (atomules) emit radiations, which like radiation, are capable of exerting pressure, then matter composed of atoms will be subjected to an attraction similar to that required by Newton's law of gravitation. In relation to this suggestion I would say that the conclusion reached is an obvious one, in view of the recent demonstration that the rays of light exert some degree of compressive force upon matter.]

FRANKLIN INSTITUTE

(Proceedings of the Stated Meeting held Wednesday, February 17th, 1909.)

HALL OF THE FRANKLIN INSTITUTE.

PHILADELPHIA, February 18th, 1909.

President Walton Clark in the Chair.

Present, 98 members and visitors. Additions to Membership since last report, 4.

The following communication from the Board of Managers was presented:

"At the stated meeting of the Board of Managers held on the 10th instant, it was

"*Resolved,* That the Board of Managers recommend that the Institute confer upon Dr. Wm. H. Wahl the title of 'Honorary Secretary.'"

On motion duly made and seconded, the recommendation was unanimously adopted.

The President announced the following Standing Committees for the current year:

Committee on Cabinet of Arts and Manufactures.

Cyrus Chambers, Jr.,
Robert Job,
H. F. Colvin,
A. E. Outerbridge, Jr.,
Tinius Olsen,
E. S. Powers,
Thomas Spencer,
H. D. Stratton,
Samuel Shoemaker,
William H. Thorne.

Committee on Cabinet of Models.

George S. Cullen,
Kern Dodge,
Spencer Fullerton,
Francis Head,
Henry Howson,
R. L. Humphrey,
Werner Kaufmann,
Strickland L. Kneass,
Coleman Sellers, Jr.,
Warner Walter.

Committee on Meetings.

James S. Rogers,
James Christie,
Kern Dodge,
J Logan Fitts,
Prof. Lewis M. Haupt,
Coleman Sellers, Jr.,
Washington Jones,
J. Y. McConnell,
Paul Thompson,
Dr. W. J. Williams.

Committee on Cabinet of Minerals and Geological Specimens.

Dr. Andrew A. Blair,
Prof. Amos P. Brown,
Dr. Persifor Frazer,
Dr. F. A. Genth, Jr.,
Dr. E. Goldsmith,
Dr. William H. Greene,
Dr. Edwin J. Houston,
E. V. d'Invilliers,
Prof. Arthur J. Rowland,
Dr. William J. Williams.

Committee on Library.

Edwin S. Balch,
W. H. Gartley,
Richard Gilpin,
Prof. Lewis M. Haupt,
Dr. H. F. Keller,
Dr. Henry Leffmann,
Louis E. Levy,
Edward S. Miles,
C. E. Ronaldson,
Dr. George F. Stradling.

Committee on Meteorology.

Clarence A. Hall,
Frank S. Hand,
Carl Hering,
Dr. George A. Hoadley,
W. N. Jennings,
Joseph T. Richards,
Henry Pemberton, Jr.
Prof. L. F. Rondinella,
Dr. Wilbur M. Stine,
George S. Webster,

Prof. W. S. Franklin of Lehigh University, South Bethlehem, Pa., the speaker of the evening, was then introduced, and made an interesting address on the Gyroscope and Its Applications. The elementary dynamics of the Gyroscope and its various applications were considered. Special attention was given to its application in the Brennan Monorail Car.

The lecture was illustrated by apparatus and a model of the Brennan car in operation.

At the close of the meeting a vote of thanks was tendered the speaker.

Adjourned.

JAMES CHRISTIE,
Secretary.

LOUISIANA WORK IN WOOD PRESERVATION HAS GOOD RESULTS.

A CO-OPERATIVE agreement between the Forest Service and the North Louisiana Telephone Company for the investigation of economic methods for the preservation from decay of loblolly pine telephone poles has recently been carried out with gratifying results. The object of the government was to demonstrate that a creosote treatment could be applied successfully and at a low cost to loblolly pine poles. Such success was obtained that a company has been incorporated under the name of the Louisiana Creosoting Company, which will operate commercially the plant designed by the Forest Service.

The treating plant, which has been in operation since the latter part of October last, is of the "non-pressure," or "open tank" type. The installment of this style of plant costs much less than a plant of the "pressure" type, which is the ordinary type of plant for commercial purposes throughout the country. The "open-tank" system depends fundamentally upon the immersion of timber first in a hot bath of the preservative, followed by a rapid change to a cold bath. This method does away with the installment of high pressure and vacuum pumps and a treating cylinder of massive construction to withstand a high internal pressure, which are necessitated by a plant of the pressure type. It is usual, however, to install a treating cylinder of light construction where any great quantity of material is to be treated, since the cost of handling the material and loss of preservative through volatilization during the hot bath is in this way reduced to a minimum. Extensive experiments carried on by the Forest Service in recent years, have shown that the "open-tank" system is admirably adapted to the treatment of certain classes of timber, and especially so as regards loblolly pine.

The plant used in the experiment with the North Louisiana Telephone Company is equipped with a horizontal treating cylinder 50 feet long and 6 feet in diameter. It was designed by the Forest Service whose representative also supervised the construction and operated the plant for several months. During this period, 3,000 poles, 2,500 cross-arms, and 500 ties were treated, an amount sufficient to determine the most economical methods of treating these classes of material. The Forest Service therefore withdrew from the co-operation, and the plant is now being successfully operated by the owners.

GOLD AND SILVER MINING IN THE UNITED STATES IN 1908.

PRELIMINARY STATEMENT BY THE GEOLOGICAL SURVEY.

Gold.—According to a special press bulletin prepared by Waldemar Lindgren, of the United States Geological Survey, the gold-mining industry of the United States had a successful and prosperous year in 1908, in spite of many adverse conditions of trade and finance. Fundamentally, this prosperity is due to the fixed price and apparently limitless demand for the product. The immediate causes operating to increase the output were in part the removal of certain abnormal features tending to depress the production in 1907, such as the partial closing of the Homestake mine in the Black Hills of South Dakota and the labor difficulties in the Mother Lode counties of California. To some degree the increased production of gold is also indirectly due to the closing of many mines in the base-metal camps. A tendency toward increased production by small operators was noted as early as the last months of 1907 and continued through 1908. Large numbers of miners left the districts in which the output of lead, copper, and zinc was curtailed and began placer work or took up leases in gold-mining camps.

The Director of the Mint estimates the production of gold for 1908 from domestic sources at $96,313,256, against $90,435,700 in 1907. South Dakota, Alaska, California, and Colorado show large estimated increases, ranging from $2,000,000 to $3,600,000. The estimates for Utah indicate a decrease of about 1,200,000; for Nevada a decrease of 3,300,000. The production of Montana, Arizona, Idaho, Oregon, and other silver producing States has remained approximately stationary. The production from the Philippine Islands shows a gratifying increase, the estimate of the Mint being $306,708, against $78,700 in 1907. As part of the Philippine gold does not reach the United States mints the showing is probably even better than these figures would indicate. Most of the gold was recovered by quartz mining in Benguet and by dredging operations in Paracale.

The depression in the base-metal industries did not affect the gold production to any considerable degree, for the total base-metal ores contribute only 9 to 10 per cent. of the normal output of gold for the country. The gold from copper ores suffered little reduction, but the small amounts contributed from lead and zinc ores were much reduced.

Silver.—The silver-mining industry presents a far less satisfactory condition than that of gold, owing to the low prices for silver, lead, copper, and zinc. During the year the large smelters of Utah and Colorado were partly closed and partly operated on a reduced capacity. Important mines in Leadville, Aspen, Creede, and Park City, Colo., which were operating on low-grade ores, found it very difficult to make profits on ore of the same grades that yielded well in 1906 and 1907, and were therefore compelled to reduce their output or to close. Owing to temporary lack of demand from India the silver market declined almost continuously from about 56 cents per ounce in the early part of the year to about 48 cents in December, the average price being 53 cents. The year closed with New York prices at 50 cents. However, the purchases by India during past years have been large and have steadily increased, and there is no reason to expect a sudden falling off in this market. The extraordinarily heavy production of the Cobalt district in Canada, which for 1908 may approximate 17,000,000 ounces, undoubtedly contributed to the depression in the price of silver. A great reduction in the output of silver in the United States was clearly foreshadowed in the figures of the Geological Survey for the mine production of 1907, which amounted to only 52,500,104 fine ounces, whereas the refineries and the mints reported 56,514,700 fine ounces. The shortage in the mine output for the last months of 1907 was naturally reflected in the refinery returns for 1908, and was accentuated by still further reduction in the production of the mines. The Director of the Mint estimates the production of silver in 1908 from domestic sources at 51,798,053 fine ounces.

BOOK NOTICES

A Short Pharmaceutical Chemistry. Inorganic and Organic, by I. V. Stanley Stanislaus, M.S., Phar.D., Professor of Pharmacy and Organic Chemistry and Dean of the School of Pharmacy at the Medico-Chirurgical College of Philadelphia, and Charles H. Kimberly, B.S., (in Pharmacy) Ph.D., Professor of applied Chemistry in the School of Pharmaceutical Chemistry of the Medico-Chirurgical College of Philadelphia. Second Edition. Philada. D. Blakiston's Son & Company. Limp cloth, 5 x 7 inches, ix + 610 pages.

The text has been prepared from lectures and laboratory notes particularly intended for students of Pharmacy and the aim has been to present a systematic course in the subject with this object in view.

In revising the work for second edition, progress in the science during the period of eleven years that have elapsed since its first appearance has been borne in mind and the original matter fully revised.

Both Inorganic and Organic Chemistry are covered, condensed as far as possible by the omission of non-essentials, by reason of the limited time available to the study of Chemistry in a course in Pharmacy.

The book is conveniently arranged for quick reference and should well fulfil its intended object. L. E. P.

Annuaire pour l'an 1909 publié par Le Bureau des Longitudes, avec des Notices Scientifique. 4 x 6 inches, paper cover: iv + 940 pages; price 1 fr. 50c. Paris, Gauthier-Villars, Quai des Grands-Augustins, 55.

Adhering to their usual custom of presenting each year papers on special subjects by authors of note, the publishers, this year, in addition to the standard data and tables relating to astronomy, physics, chemistry and engineering, include papers on Variable Stars by G. Bigourdan and on Motions and Deformations of the Earth's Crust by Ch. Lallemand. The work is a national standard and the data contained may be accepted as thoroughly reliable. L. E. P.

The Present Status of Military Aeronautics. By George O. Squier, Ph.D., Major Signal Corps, U. S. Army. iv + 71 pages, 6 x 9 inches, paper covers. 23 full page illustrations, diagrams, and tables. Reprinted from The Journal of the American Society of Mechanical Engineers.

Many of the important advances made in the act of transportation have received their first impetus and much of their subsequent development through the necessities and exacting requirements of military service. The presentation of the first paper reviewing the subject as a legitimate branch of engineering before the National Society of Mechanical Engineering by a military technologist is, therefore, an occasion of undoubted significance.

The most modern and successful derigible and aëroplane apparatus evolved both in this country and abroad are described in considerable detail along with the general considerations involved in both forms of apparatus. In an appendix are given the recent Government specifications for heavier-than-air flying machine and dirigible balloons in accordance with which were built the several forms of airship tested at Fort Meyer, Va., a short time ago. The appendix concludes with a sixteen-page bibliography and a list of aëronautical societies at home and abroad.

The student of aërodynamics seeking reliable information upon the latest advances in the art will find the paper true to its title. L. E. P.

Dr. William Henry Wahl

Secretary of the Franklin Institute
1870-1874, 1882-1908

Honorary Secretary
1909

Died

March 23, 1909

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FRANKLIN INSTITUTE

IDENTIFICATION OF HUMAN BEINGS BY THE SYSTEM OF ALPHONSE BERTILLON.

BY
PERSIFOR FRAZER.

INTRODUCTION.

IN the early part of a sojourn of over a month which I made in Paris last fall, I called upon M. Bertillon, the inventor of the famous system of identification which bears his name, as we had been in correspondence for many years. I was most cordially received and taken by him over all the departments into which his identification service is divided, and when an eruption of crime in the "City of Light" during last summer and autumn which exceeded anything recorded in its annals, caused a constant demand for M. Bertillon's personal services, he most kindly placed at my disposition one of his trusted assistants, who seemed to be "primus inter æquales," inasmuch as to him was intrusted the duty of instructing the officers and men of the entire police force of Paris in the Bertillon system. This gentleman was still untiring in his efforts to place in my possession complete information of the subject up to date, including many very

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* A lecture delivered in the Franklin Institute Popular Science series, Feb. 15, 1909.

[NOTE.—The Franklin Institute is not responsible for the statements and opinions advanced by contributors to the Journal.]

important procedures and methods which have never been published to this very afternoon. To this end, in addition to giving me detailed information of the apparatus for taking the measures, and the many various objects employed in teaching, he has written out quires of foolscap sheets giving the most intimate details of the work; and up to the present time an almost constant stream of very valuable charts, photographs, plans, and descriptions have been flowing from M. Bertillon's office in Paris to mine here. M. Bertillon expressed the pleasure it would afford him if I would make of my studies a popular lecture.

IDENTIFICATION OF HUMAN BEINGS BY THE SYSTEM OF ALPHONSE BERTILLON.

USE OF PURE RESEARCH.

In answer to the question, What is the value of a newly discovered *provisional* fact or law in science? (for science deals with no other kind), the illustrious name-saint of this Institute replied, "What is the value of a new-born infant?" As time goes on we get a specific reply to each specific query. This is notably the case regarding the subject with which Benjamin Franklin has so closely identified his name,—Electricity,—with its twin sister Galvanism. In the middle of the eighteenth century people regarded with awe the sparks which Franklin drew from his kite, and with child-like laughter the grimaces of the folk who took the spark in the ring with joined hands, the comical antics of the pith-balls, and the kicking of a pair of dissected frog's legs. The conservatives agreed that all of this was very imposing, or very funny, but what use was it? Franklin was the first to find an answer in the lightning-rod, which from that date to this, when properly constructed, has never failed to protect a building from the dreaded stroke. And in succession the telegraph, the electrotype, the motors which daily carry millions of people myriads of miles and countless burdens from the bowels of the earth and the sea to the surface, the incandescent and arc lights, which have almost superseded all other means of illumination, the Becquerel and Hertzian and Röntgen waves, children of electricity which penetrate human bodies and great timbers and limitless space calling aid to the ship sinking in mid-ocean, in man's service,—these are answers to that question, "Of what use is it?"

Probably in time every scientific discovery will have an equally definite reply of a similar kind. Alphonse Bertillon's system of judicial identification (or "Bertillonage") is such a response to the question, Of what use is anthropology?

ANTHROPOLOGY.

In the middle of the last century this science was founded, and Louis Adolphe Bertillon, the father of Alphonse Bertillon, was one of its sponsors in France. He was born in Paris in 1821, received his degree of M.D. in 1852, and prizes from the Academy of Medicine in 1856 and 1858. After the revolution of 1870 he was made Mayor of one of the Arrondissements of Paris, lectured on anthropology in 1876, and was widely known as a statistician on demography, socialism, and medicine.

Alphonse Bertillon.

His son Alphonse was born in 1854, and doubtless through his father's influence was drawn to the study of social and anthropological questions and hence to anthropometry and penology.

Whatever the incentive, these studies culminated in the adoption at the end of 1882 by M. Camescasse, Préfet de Police, and M. Vel-Durand, Secretary General, of the system conceived by M. Bertillon and proposed to the Administration in 1879. Subsequently M. Herbette, Director of Penitentiary Administration, extended it throughout France and warmly supported M. Bertillon in his presentation of the subject before the Penitentiary Congress of Rome, in November, 1885. The end sought by these officers was to facilitate the execution of the law of May 20, 1863, by destroying the pretexts of "first offence" and "somebody else" which had long served the old offenders.

SCIENCE AND ART.

In assuming that every actual discovery of a (provisional) fact or law will ultimately lead to a useful application, I am saying that every (provisional) law of science or group of such laws will lead to an art. It is well to remind ourselves here that the words science and art in the crude word-mills of current literature are confounded, and often distorted. In all that I shall have to say here I use the word Science as study of law; Natural Science as study of the laws of nature; and Art as the application of such studies to the practical use of man. Thus, from optics and physiology can be evolved the laws of color and color-sense; from geometry, the laws of perspective; but the painting of a picture is an art which applies these laws to a definite purpose evolved in accordance with laws of psychology in the painter's brain. The study of the human machine, or anatomy, the relations of parts of the human body to each other and the influence upon them of extraneous forces, or physiology, are sciences, but the application of knowledge of these things to the practice of medicine is an art. "Scientific" boxing, fencing, piano-, billiard-, and card-playing, training, cooking, etc., are the incongruous monsters of space-writers and may be compared to the centaurs and mermaids of our early progenitors, in that they join things together which are never joined in nature. Perhaps it would be more polite to call these vulgarisms of speech metonymy.

The science of anthropology has for its study man in all his attributes and qualities, physical and psychological, but the first or physical characteristics are those which chiefly concern us here because it was through the study of these that Bertillonage was evolved.

BERTILLON SYSTEM ACCURACY OF OBSERVATION.

The system of identification of M. Bertillon, which has proven so useful to mankind that half or more of the nations of the earth have adopted it, is not a discovery in the same sense as those of Copernicus, Newton, Laplace, and Darwin, though like them in reaching its goal by synthesis of well known and even commonplace facts, but if the aphorism be true that genius is the capacity to take infinite pains then Bertillonage is an example of the highest genius, for its successful application depends upon a delicate unperturbed appreciation of physical sensations on the part of the observer, a scrupulous accuracy in recording observable data, and the use of all the precautions known to original investigation by repetition of measurements and readings to avoid possible error. On this subject M. Bertillon says in his "Identification anthropométrique" of 1893, . . . "These measures derive their entire value from being accurately taken. If a means could be found for reducing the error of each recorded observation by one-half in each of the eight different measurements, the error of identification would be 1 divided by $8 \times 2^8 = 1 \div 2048$."

Therefore the whole marrow of Bertillonage is detail,—minute detail,—and close readings. It is this fact which makes it difficult to present the subject entertainingly to a popular audience. I shall rather endeavor to sketch in outline what it is the object of the system to accomplish, and the means employed.

ANTHROPOLOGY.

Broca, a member of the first Société d'Anthropologie, of Paris, proposed a color scale for describing the eyes and skin of different races of men.

The characteristics which he regarded as most valuable in distinguishing races were, first, the color of the skin, and, second, the structure of the skull, and their importance in the order given.

According to Retzius's method, very generally adopted by anthropologists, the longer diameter of the skull from front to back is assumed as 100. If the shorter diameter measured above the ears is less than 80 on this scale the skull is called dolichocephalic (long-narrow headed); if more than 80, brachycephalic (short or round headed). From 75 to 80 in the transverse diameter he called mesocephalic. Negroes have 72, Europeans 78, and Tartars 88, in this measure. Blumenbach recognized five races, viz.: Caucasian, Mongolian, Ethiopian, American, and Malay (E. B. Tylor, "Encyclopædia Britannica").

The application by M. Bertillon of these methods was for the identification, not of great groups of the human family,—races,—from each other, but of an individual from every other individual, and arose from the urgent need of the law courts to know whether they were dealing with old offenders (recedevistes), or whether an arrested man actually had not been previously before them.

DIVISION OF SYSTEM.

M. Bertillon's system is divided into, first, a means of identifying an individual with absolute certainty, from careful measurements taken by skilled agents, and, second, a ready means of recognizing an individual in a crowd from a description or from observations previously taken. One supplements the other, while each is useful independently of the other.

The principle upon which the measurements are based is that no things are absolutely identical, however similar they may seem. This is especially true of organic objects which grow, because it is unthinkable that two different and separate beings could be, during a number of years, subjected to exactly the same forces, and should present to these forces exactly the same resistances. Whatever it be, whether two coins struck from the same die, twins who have been fed and nurtured similarly, even two drops of water taken from the same source, a sufficiently minute examination will inevitably disclose differences which will be greater and more numerous the more searching and careful is the investigation. It is only necessary then to obtain a sufficient number of data from each individual to place upon record a description which will differ from that of any other individual analogously made.

The printed pamphlets which I have obtained from M. Bertillon containing statistics of the working of the system are the following:

"Extrait de l'annuaire statistique de la ville de Paris pour l'année 1887. Notice sur le fonctionnement du service d'identification de la préfecture de police suivie des tableaux numériques résumant les documents anthropométriques accumulés dans les archives de ce service, par Alphonse Bertillon, Chef du Service d'identification, Paris, G. Masson, éditeur, libraire de l'Académie de Médecine, 120 Boulevard St. Germain, 1889."

This contains besides a general description a series of tables of the greatest scientific interest, giving the "Mean dimensions of each measurement by age," tables *A* and *B*, with the results of the calculation with the elimination of one-half, nine-tenths, and total elimination. These same calculations are carried through all the succeeding tables. Tables *C* and *D* are "Mean dimensions for each measurement of a group of heights at intervals of 5 cm. (Parisians from 21 to 44 years)." Table *E*, "Given a measure (of some dimension), what is the corresponding height (Parisians from 21 to 44 years)?" This table is divided into span, body measure, crotch to heel, fore-arm, left foot, head-length, head-breadth, left middle finger; little finger; length of ear; color of eye (?). Table *F*, "Given the length of foot and of the fore-arm, what is the corresponding height?" Table *G*, "Given the lengths of foot and of the left middle finger what is the probable height corresponding?" Table *H*, "Given the head-length and breadth what is the probable height corresponding?"

The other pamphlet is entitled, "Bibliothèque d'anthropologie criminelle et des sciences pénales, l'anthropométrie judiciaire, à Paris en 1889, etc." Lyon, A. Storck, éditeur, 78 rue de l'hotel-de-ville, Paris; G. Steinheil, éditeur, 2 R. Casimir-Delavigne.

A third, now out of print but which I consulted in Paris, was "Identification anthropométrique. Instructions signalétiques," Alphonse Bertillon. Nouvelle édition, 1893.

A newer edition of this work is promised within the year.

What I bring before you to-night is not confined to the matter contained in the pamphlets I have mentioned nor any other printed information. M. Bertillon himself and his able assistant, M. Bertrand, have furnished me with a great deal of new material up to date which I have supplemented by notes and observations made in the rooms of the Service of Identification.

I do not in the least blame M. Bertillon for not putting in print the details and statistics of his service to date. There are criminals, perhaps the most important destined to be captured by his admirable methods, who are as intelligent as he, and who would gladly avail themselves of full statistics of his methods to escape justice. Not only in France is this true but so universally has this system been acclaimed and adopted by foreign nations that the loss to human justice would be incalculable should his minute details of procedure be so perfectly mastered by rogues that they could " take measures " also to defeat them.

There is an interest personal to myself in the history of M. Bertillon's system.

STUDY OF HANDWRITING.

An accidental connection with a case involving the examination of handwriting in 1878 turned my attention to the subject, and a few months' work in my leisure moments convinced me that it could be treated by purely scientific methods. Unknown to me M. Bertillon had commenced in 1872 (his nineteenth year) the application, to a larger and more important field, of methods in some respects similar to those I adopted, and had presented them to the authorities in 1879, the year when my first essays were made. I had employed averages of the greatest possible number of cases to avoid the error of accidental variations just as he had done a few years before. His methods like mine are anthropological, but whereas M. Bertillon employs exclusively the concrete or anthropometric, my own results are based upon the psychological branch of this science; that is, upon thought and will-power translated into action, which leave traces behind them.

SELECTION OF POINTS.

The first thing to consider when contemplating a rigorous description of a human being is what data are most serviceable, because least likely to vary, and least capable of being altered.

Only a long practical experience in anthropometry could decide this question.

In the early stages of Bertillonage many measurements were taken which are now entirely discarded.

It is evident at the first thought that the most permanent data will be found in those parts of the body which undergo the least change; in other words, the bony structure; and of all these the skull, which from an early age, in spite of its twenty-two component bone-plates, is virtually a single large bone, proves the most available for identification because important artificial alteration of its dimensions is almost or quite impossible. The pivotal point of the Bertillon measurements is therefore the skull and the relation to each other of its anteroposterior and transverse diameters.

Other measures used to differentiate the individual are the length of the left foot, the length of the middle finger of the left hand, the length of the left forearm from elbow to middle finger tip, the height in a standing position, and seated, the span of the extended arms, and the length and breadth of the right ear. The measurements in these and all other cases where bony structure is involved are made from points where the bone is covered by a minimum of integument, and no fat nor muscle interposes between it and the measuring instrument.

The measurements of the bony structure are taken from the left side, preferably, because most people are right-handed and the members of the left side suffer least from injuries.

These measures constitute the more important part of the Bertillon description, and furnish the means of classifying the records of an individual in the box files, which latter form one of the most astonishing parts of the whole system and one without which the others would be absolutely valueless.

But these are only a few of the observations and measurements actually taken when it is desired to have a complete record of the individual. With the increased experience which the practice of this system for twenty-six years has brought, various additions to the armory of identification have been made, and notably two of the utmost importance, viz., the study of the finger-prints, first systematically applied in modern days by Sir William Herschel when he was "Collector," or chief administrator, of the Hooghly district in Bengal, and presented to the scientific world, with the thoroughness and accuracy which distinguish all he has done, by Francis Galton in 1888. The other, a careful determination developed by M. Bertillon of the shades of color exhibited by the human iris, classified by the increasing intensity of its yellow-orange pigmentation. While the accurate description of this characteristic requires an extremely delicate color sense and great experience on the part of the describer, it furnishes a datum, M. Bertillon asserts, as unchangeable as the dimensions of the skull.

A mounted chart of these colors is beside me. It can be procured by application to M. Bertillon.

PORTRAIT PARLÉ.

But besides these principal features of the classified description of an individual, M. Bertillon has added a large number of others for the use of the police where accurate measurement is out of the question but recognition on the street or in a crowded room is the object. These are the features of what he has aptly called his "portrait parlé" or described picture which can be telegraphed from one end of the country to the other, and thus enable a distant policeman to recognize and apprehend a fleeing transgressor.

In this described picture the points to which the attention of the detective is directed are the following:

1. NOSE: Profile of the line of the ridge of the nose, is it (*a*) concave, (*b*) straight, (*c*) convex, (*d*) arched or hooked ?]

2. EAR LOBE:
    - (*DEQ*) descending or square
        - (*TRA*) furrowed.
        - (*SEP*) the lobe separated from cheek.
    - (*CAR*) antitragus concave or straight . . (*SA*) antitragus profile prominent.
    - (*VEX*) lower fold convex . . . . (*X*) absence of preceding characteristics.

3. EYE: (*j*) yellow, (*or*) orange, (*ch*) chestnut, (*mar*) dark chestnut, (*as*) azure, (*i*) intermediate violet tinge, (*ard*) slaty, (*v*) greenish.

4. HAIR AND BEARD: (*bl*) blonde, (*ch*) chestnut, (*rx*) brownish red, (*grs*) grisly, (*cl*) light, (*m*) medium, (*f*) dark.

SPECIAL MARKS.

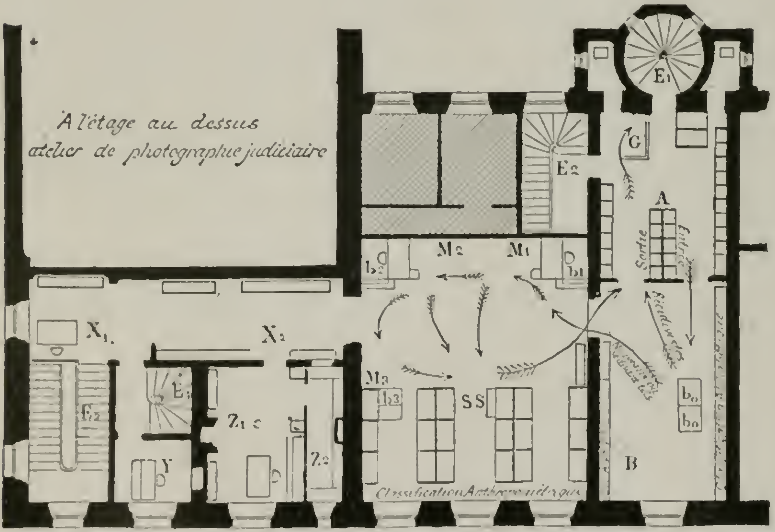
Following these in the D.K.V. book shortly to be described there are one hundred abbreviations to one or two letters of words to describe cicatrices, moles, mutilations, boils, sores, etc., which may be of great value either for recognizing an individual or for confirming the probability of his correct identification.

SAINTE CHAPELLE.

A word or two may be here devoted to the location of the service of identification in Paris.

On the island of the city where the first stronghold (then called Lutetia) was built in the time of the early Roman empire, there stands a noble old palace, which served during the middle ages as the home of the French kings. Close alongside of it is one of the most beautiful specimens of Gothic architecture in the world, the Sainte Chapelle, built by St. Louis to house the relics he brought from his ill-starred crusades, and especially the crown of thorns sent from Constantinople. This wonderful little architectural gem is buried in the shadows of the greater buildings which surround it, the immense Palais de Justice, and the depot, or central police station, of the préfecture de police.

FIG. 1.



This enormous palace of justice has been extended and partially reconstructed, and on its west side facing the Place Dauphine it presents a superb Greek façade which was erected during 1865–70. On entering the building one is bewildered by its vastness. Avenues as broad as streets and bearing names like streets traverse it from east to west, and are intersected by cross avenues through which one may see the advocates darting hither and thither in their gowns and academic hats. The corridor from which one ascends to the rooms which are employed by the service of identification is called that of "Sainte Chapelle" because only separated from that unfortunate and beautiful structure by the south wall and the rooms thereto adjacent.

It is difficult to imagine a bureau better situated for its purpose, close beside the depot which receives all the prisoners arrested for petty and grave offences within the department of the Seine, and communicating with it by a private door and stairway. The depot is less a prison than a vast central post where all the thieves, mendicants, vagabonds, etc., arrested the day before in the department of the Seine, await their appearance before a court of justice.

> The only exceptions are those who are arraigned before the Courts "in a state of liberty" for minor offences and condemned to a few days of prison. This category seldom contains professional malefactors. Their detention in the depot does not exceed twenty-four hours, during which time they are "Bertillonized" to the number of 80 to 150 or more a day. This procedure is effected in the early morning, so as not to interfere with the examinations before the magistrates. Only three or four hours are therefore available for taking measurements of this great crowd. Six or seven at a time are brought by agents of police up the spiral staircase to the rooms where the measures are taken. On their arrival they take their places in twenty-six little stalls arranged along the wall and in the middle of the room, and here remove a part of their clothing and foot-gear, retaining only their shirts and trousers.

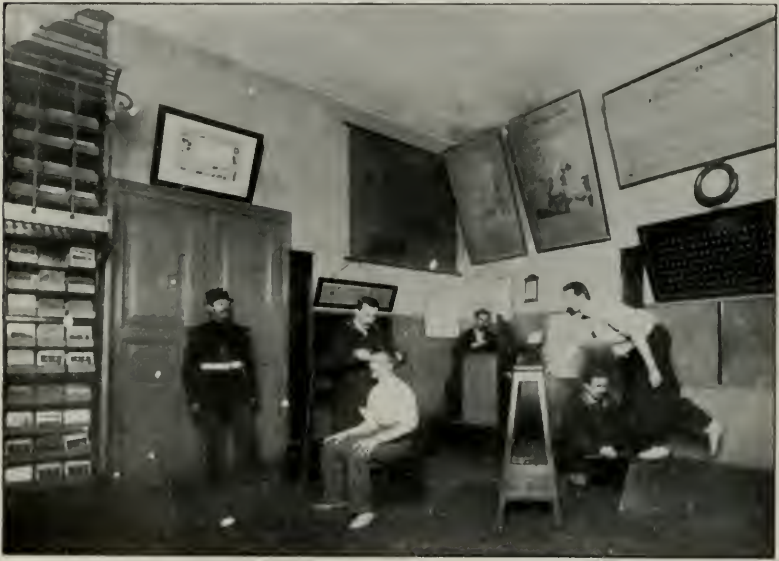
FIRST TEST.

Each hangs his garments on the nails with which the stalls are furnished until the measurements are completed and passes directly to a connecting large room in the rear furnished with shelves holding index files in boxes called cabriolets, reaching from the floor to ceiling, and containing the Bertillon registers of those who have been previously measured, classified *alphabetically* by the names and social conditions they have given.

In this room the first test is made. About half of those arrested give their real names, and for such the inquisition is ended as soon as the measuring instruments are adjusted to the values recorded and applied to the respective objects of measurement for verification, and a rapid examination is made to verify the peculiar marks recorded on each card.

This identification is confined to the two measurements of the head with callipers fixed successively to the figures given in the description already on file. These two data taken and corroborated to a millimetre ($^1/_{25}$ in.) are amply sufficient to determine whether or not the prisoner has told the truth.

FIG. 2.



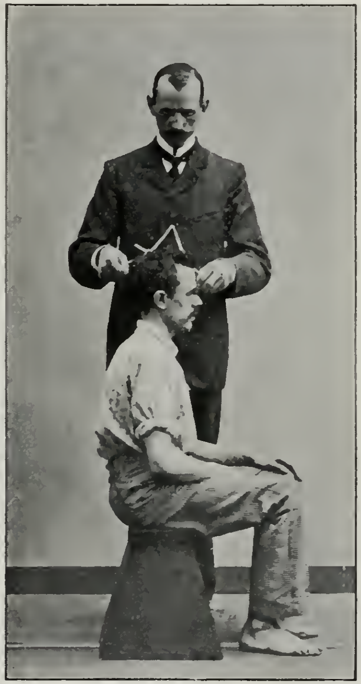
It is thus at once seen whether the same individual is present and if so no further measurement is made.

The agent marks "idf" (identified) on the back of the card with the new data, and signs his initials and the prisoner returns to the room he has just left and re-clothes himself.

In the case of a young person whose growth might cause a discordance with the data obtained, or of an offender who has not been arrested more than once before but of whom it is important to preserve the record because he is likely to be or become an habitual criminal, the examiner marks "vrf" instead of "idf," which means that the verification has been made of all the points noted in the first description. The figures then recognized as erroneous are replaced by new and accurate data. Where there is no change the mark of equality (=) is entered, meaning that the complete verification has been made.

With adults the complete verification of all data is made only at long intervals, say ten years, whereas on the contrary minors are subjected to it at each arrest even if the interval be but a few months.

FIG. 3.



When the same offender has been identified five times he is banished.

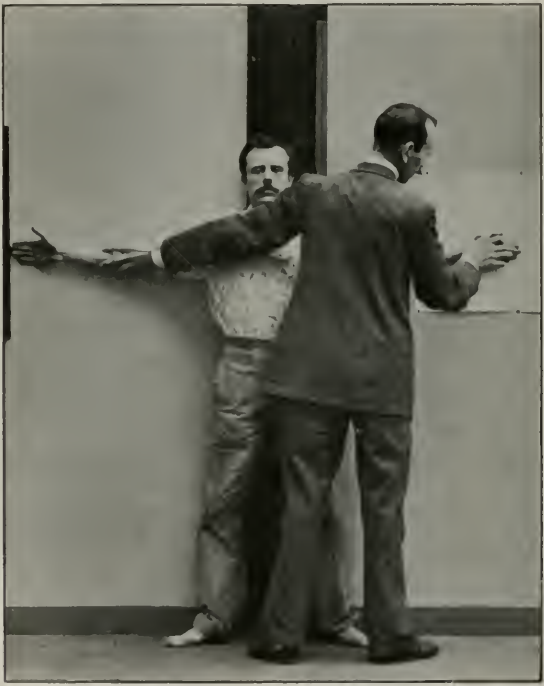
Only those who are for the first time arrested or who deny their identity are passed to the second room of the service.

As rapidly as possible those who are subjected to a further examination are called into the large adjoining room where three separate sets of measurements can be undertaken at the same time. In each case the same agent obtains the anthropometric measurements, the portrait parlé description, and the peculiarly characteristic marks, which are recorded by a clerk occupying an elevated desk very much as the measurements are taken in the better class of tailor shops.

Some observations may be permitted concerning the way in which the measures are taken.

The Long Diameter of the Skull.—This is obtained by means of adjustable callipers with a binding screw to fix the arms at any position. The measure is made from the cavity at the root of the nose to the point of greatest protuberance of the occiput. Two measures are made to control each other.

FIG. 4.

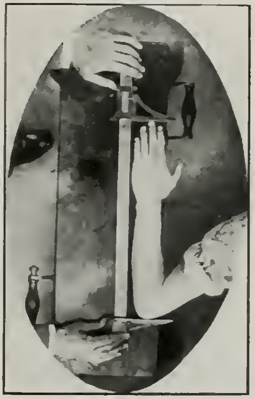


Transverse Diameter of the Skull.—This is taken by means of the same callipers and is the maximum distance apart of the parietal bones which are situated above the superior border of each ear. The measurement is rather difficult because there is no fixed point of departure like the cavity at the root of the nose, and care must be taken not to displace the arms of the callipers on both sides of the head at the same time. An excessive breadth of head indicates the brachycephalic type. The breadth of the head of an adult male in France varies between 153 and 158 mm. (6.06 to 6.22 inches).

Length of Middle Finger (*or of Little Finger*).—The two fingers are measured by means of the same sliding rule, the finger being first bent until it is at right angles to the back of the hand. It is taken to half a millimetre ($^1/_{50}$ inch).

It follows necessarily that in order to secure this accuracy neither fat nor muscle must intervene between the bone and the plane of the instrument. This is most readily accomplished when the hand forms an angle of about 137 degrees with the wrist and the finger a right angle with the back of the hand. The measurement is, of course, from the bone of the first joint to the tip of the finger.

FIG. 5.

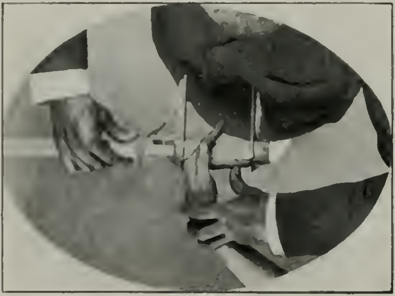


Span.—The graduated rod for the span is also fixed horizontally to the wall. A vertical strip is fixed to the wall midway between two height measures. The end of the middle finger is placed against this, the arms are extended horizontally and that farthest from the strip covers a part of a rectangular board on which vertical lines indicate centimetres. The edge of the board at which the centimetre marks begin is just one metre from the strip above described. The measure is to the extremity of the middle finger of the other hand.

Left Forearm.—A wooden horse 1.19 M. (+ 3.8 ft.) high supporting a board 0.8 M. (+ 2½ ft.) long and 0.25 M. (+ 8 inches) broad serves for a rest of the arm. The subject is made to take a position leaning slightly forward and to place the bare forearm on the board. A shoemaker's measure is then adjusted so that the fixed end touches the bone at the elbow and the movable part the extremity of the middle finger. The average length of forearm for an adult in France proves to be 44.5 to 45.3 cm. (17.46 to 17.79 inches).

Height.—The subject is not placed so that his back is against the fixed metre staff attached to the wall, but to one side. The measuring arm projects toward the subject and records on the rod attached to the wall. This enables the measurer to see that the subject is standing on his heels, the legs together, the back and occiput against the wall, and the figure perpendicular to the floor. The reading is to the nearest millimetre ($^1/_{25}$ inch).

FIG. 6.



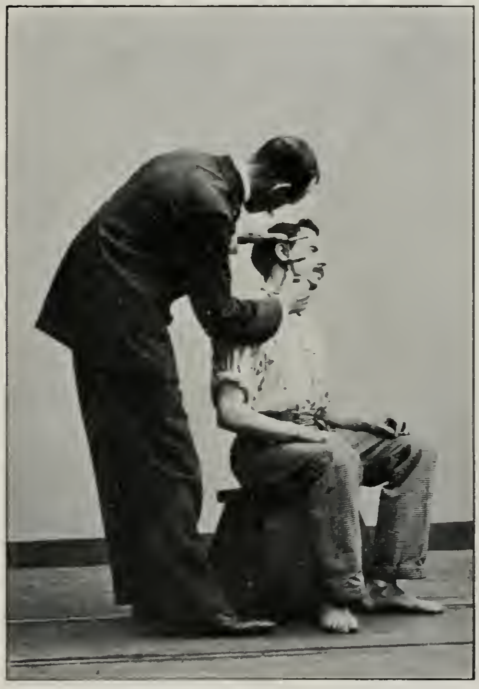
Body Length or Bust.—What is called the bust is the trunk and head or the height of the figure in a sitting posture.

The graduation for this measurement is from 0.70 M. to 1.20 M. (1.55 ft. to 3.9 ft.).

The Right Ear.—It is of course preferable to measure the feature given in the photograph of the subject, which is on the right side. The subject's head is inclined to the left and backward. The length is obtained with the aid of a sliding measure from the upper to the lower edge of the ear, the latter called the *lobe.* The average length of right ear for a French adult is 63 mm. (2.48 inches).

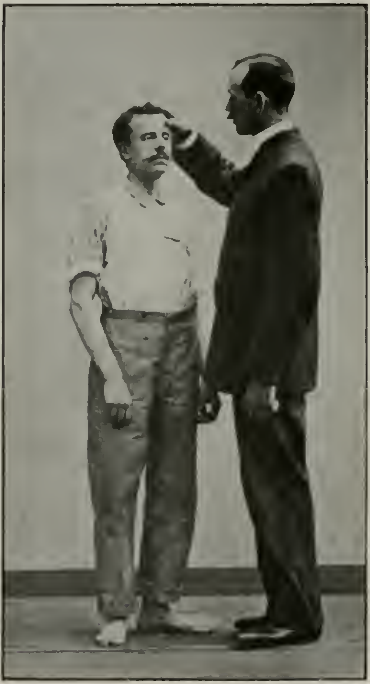
The Examination of the Left Eye.—The eye is a means of identification as important, in M. Bertillon's estimation, as the marks of the finger prints. The color does not change with age. So far as its color is concerned, M. Bertillon asserts, the eye is unchangeable from birth to death. The conditions under which it is observed may change, and this may lead to a false impression. It ought never to be examined in a false light. The subject whose eye is to be described should receive a strong light (but not the direct rays of the sun) full in the eye. M. Bertillon has made a table of seven categories of color which are beautifully printed in chromotypogravure by the Maison Gillet of Paris, copying paintings in oil colors from models in nature by Felix Geoffray under M. Bertillon's direction, and have been mounted on a card. The categories are based on the increasing intensity of the yellow-

FIG. 7.



orange pigment. The pigment is a reddish- or brownish-yellow animal matter which gives to the eye diverse tints. When the pigment increases in quantity in an iris, the eye from the point of view of its color, and of the number in its class, increases also. In other words, the more pigment an eye contains the more it appears dark and close to the extreme type of pure horse-chestnut color. Eyes called unpigmented are not deprived of all color, but are uniformly blue, and the opposites of the pure horse-chestnut brown color. This type of eye is found among the Slavs, and the people of the North, the other type among the negroes, the Arabs, and more generally the dwellers in the South.

FIG. 8.



Between these two extremes are intermediate classes numbered 2, 3, 4, 5, and 6 which indicate in the order named the eyes in which the yellow is that of flowers of sulphur (2), rind of lemon or orange (3), the color of the shell of a chestnut dry and powdery (4), the color of horse-chestnut in rings but not covering the entire iris (5), the color of the horse-chestnut of the Indies with a tinge of green (6), and finally, the color of the shell of a ripe and fresh horse-chestnut with velvety surface.

The Left Foot.—All the measures of the members of the body are taken on the left side; first, because the left side is that opposed to the right of the operator facing the subject and usually easier for him to reach; and, second, because most people being right-handed there are fewer wounds, amputations, and other results of accidents on the left side than on the right; and this fact is important when one reflects that the measurements are almost exclusively of the bony structure. To obtain the maximum length in measuring the foot the subject stands on a stool on one foot, leaning forward. This brings the entire weight on the foot and forces the toes forward to their complete extension. The instrument of measurement is the extensible shoemaker's rule, one part being placed against the heel and the other against the point of the great toe. The average length of the left foot in French male adults is from 25.5 to 26.1 mm. (10 to 10.25 inches).

The Bi-zygomatic Diameter.—This measure has in part replaced that of the right ear. It is taken by means of the same callipers, between the osseous bands which terminate above the auditory canal and behind the cheek bones. The ends of the calliper must be kept horizontal and the measurer should be as close as possible to his subject. Neither hair of the head or face, nor fat prevents the accurate estimation of this diameter, which increases and diminishes with the other cephalic measurements. In French adults it varies between 137 mm. and 138 mm. (about 5.39 inches).

As an example of how the divisions very small, small, medium, large, and very large as applied to the ear, are distributed in M. Bertillon's office the following will be of interest:

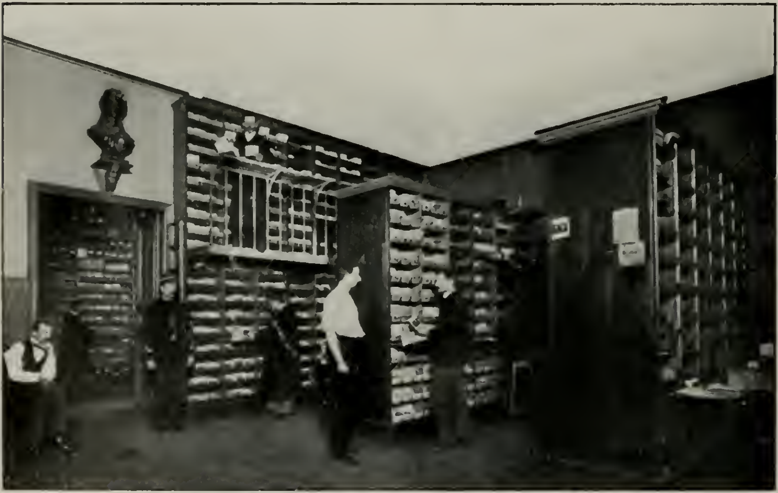
Very small	55 mm.	(2.17 inches)
Small	58 mm.	(2.28 inches)
Medium	63 mm.	(2.47 inches)
Large	70 mm.	(2.74 inches)
Very large	75 mm.	(2.94 inches)

Particular Marks.—These are sought on the arms, and trunk especially, but any scar constitutes such a mark and may be of great value in determining identity. Whether tattoo, cicatrix, tumor, or common mole, each of these kinds of marks is furnished with an abbreviated symbol of a couple of letters and is carefully measured by a millimetre rule from the nearest fixed objective point on the body or limbs.

CONVENIENCE OF RECORDER.

M. Bertillon rates very highly the advantage of saving from the annoyance of making notes the agent who is making measurements and observing the characteristics of the subject. He also attaches great importance to his system of abbreviations which saves much unnecessary writing.

FIG. 9.



Of these measurements and descriptions, in Paris one copy is made, the rough notes being used for the alphabetic, and the copy for the anthropometric collection of the capital. In Lyons and Marseilles (which keep services of records like that of Paris) three copies are necessary: one for the city where they are taken, and two for Paris.

As soon as the data are obtained the subject is sent with his record-slip to the agent of the anthropometric section who attends near the large stacks of records in the rear of the measuring room. This officer, whose eye is trained to run rapidly over the record-slip, notes at once whether any important datum has been omitted, either there or on the back of the slip containing the prisoner's account of himself. In case of any omission he sees that it is supplied, and then classifies, by putting into their respective places, the records of the persons examined.

> The subjects of examination having completed the cycle required of them return to their stalls and dress themselves. As anthropometry furnishes sufficient means of identification to detect an old offender (measured after reaching maturity) the préfecture of police only requires photographs of those under 21 years. If over that age only those of whom the police wish a portrait to facilitate or hasten an investigation are conducted to the photograph gallery.
>
> As the separation of the persons in the rooms of the identification judiciaire is not absolute, the chief of the préfecture de police takes care to send there in different squads the various individuals inculpated in the same affair. Dangerous criminals or those persons of whom a very particular description is desired, are sent to the measurers during the afternoon.

The service comprises two sections: (1) of anthropometry, and (2) of photography.

The employés of these two sections number eight agents, of whom one is a brigadier detached permanently from the service of the department of safety, a principal inspector having authority over both, and the chief of the service M. Bertillon.

To be continued.

SCOTCH FULLER'S EARTH.

There are many varieties of this material varying both in chemical composition and in physical qualities, and while the former is well known from the result of analysis the latter have never been very clearly understood. Consequently chemical analyses are of comparatively little value in determining for what purpose the earth is exactly suited, which can only be ascertained by practical experiment and experience.

The manufacture of fuller's earth is carried on in various ways according to the variety of the material and to the purpose for which it is required. The simplest process is that in which the crude earth is dug and kiln-dried, while it may be further treated by being ground to a fine powder, say 120 mesh, in which latter form it is largely used by manufacturers for refining purposes. In other cases the crude earth, after being mined or dug, is ground and washed, sand and other impurities being taken out by specially constructed sand traps and revolving sieves, then deposited in large tanks and afterwards kiln-dried, when it takes the form of lumps and is used for cleansing and fulling cloth, etc. The lump earth is also reground, purified, and reduced to different grades and classes of powder according to the purposes for which it is required.

In Scotland the only known deposit of fuller's earth is at Keltie, Dunning, and Perthshire, where there are large quantities of different kinds.

Consular Report.

ELECTRICAL SECTION

(*Stated meeting held Thursday, February 18, 1909.*)

TUNGSTEN AND OTHER LAMPS.

BY

GEORGE LORING.

We will briefly consider the manufacture and performance of the electric illuminants, having filaments operating in vacuo, which are proving commercially successful to-day in this country. They are known as carbon, gem, tantalum, and tungsten lamps.

The carbon lamp, at the time of its introduction commercially,—1879,—had a so-called efficiency of less than 4 w. p. c., which, in the course of sixteen years or so, was improved to 3.1 w. p. c. Then, for more than ten years, this illuminant practically stood still as far as decreasing its current consumption was concerned. Finally, in 1905, a decided improvement took place, the efficiency of the lamp being increased to 2.5 w. p. c. In less than twelve months after this advancement had been made, manufacturers brought out and placed upon the market the tantalum lamp, with an efficiency of 2.2 w. p. c., which, within a short while, was changed to 2 w. p. c. On January 1, 1908, an American-made lamp, having an efficiency of 1.25 w. p. c., with filaments constructed of tungsten, was offered for sale in this country.

It will be seen that during the past four years the electric incandescent lamp has increased 60 per cent. in efficiency, although during the twenty-six years preceding that time the improvement along the same line was approximately only 25 per cent.

MANUFACTURE OF CARBON LAMPS.

We will consider the manufacture of the illuminant known as the carbon filament lamp.

Building the Filament.—Cotton is placed in an acid, changing it into a mass form a trifle thicker than molasses. This is put into a bottle, and forced through a small outlet in the bottom of it, in thread form, by an air pressure from above, falling into a hardening mixture contained in a jar. It then goes through another process, after which it is washed free from acid in water. Next it is wound on drums and left to dry. While doing this it shrinks to about one-third of its first size. After being taken from the drums it is gauged for size, wound on forms and placed in a graphite crucible. It is then baked at a very high temperature for a few hours, unpacked and gauged by resistance per inch, cut to proper lengths according to the voltage and candlepower for which it is intended, treated in a gasoline gas for resistance by apparatus which automatically cuts out when the correct point is reached, tested for spots, counted and packed into boxes ready to go to the mounting room.

Leading-in Wires.—The leading-in wires of all lamps have a certain amount of platinum welded to the ends sealed within the stem. The platinum is cut automatically by machine. The wires are cut by hand. The copper is welded to the platinum, the former melting while the latter does not. Inspection takes place. The leading-in wires are then packed and are ready for use.

Stem.—A stem is made from a flange tube which has previously been sorted from others for diameter and thickness. This is necessary as the dimension of the stem ofttimes varies with the size and style of lamp into which it is going. We will select one flange tube (Fig. 1) and follow it through the factory.

It goes to a machine which automatically puts a flange upon it (Fig. 2). It is then taken to another device and placed in same, flange up, the other end resting upon a block. Two leading-in wires 3 inches or more in length with platinum tips are placed in the flange tube. The platinum end of each wire rests in a separate depression in the above-mentioned block. Gas flames are directed against the tube, covering the last ¼ inch of the end which is not flanged. Jaws come up automatically and press this section of the tube together, sealing in the copper wires in such a way that the platinum starts about ⅛ inch from the end of the seal and protrudes for an equal distance; at the same time, when an anchor is used, it is automatically inserted into the glass. The stem is then annealed, inspected for quality and if satisfactory is sorted into the proper stock division. If the stem has an anchor it is given to an operator who cuts it to the proper length, and if necessary bends it at the end (Fig. 3).

Mount.—The carbon is now mounted upon the stem, this being done by connecting the filament to the proper wire terminals or supports. A graphite and suitable binding material paste is used in this work (Fig. 4). The mount is then straightened and inspected for every conceivable error. If satisfactory it is baked in an oven in order to make the joints absolutely secure. We will now give our attention to the bulb into which the mount is ready to be placed.

Bulb.—The appearance of the bulb when received by the lamp manufacturer is shown in Fig. 5. Tissue paper surrounds it. This is removed and the bulb with others is placed in a tray, clamped down to hold it fast and submerged in a tank of water. After being thoroughly washed it is allowed to dry naturally. It is then moved to a machine where a hole is made in the centre of the large end. This is accomplished by applying a pointed gas flame to that spot and sending an air pressure down through the neck. What is known as the top tube, shown in Fig. 6, is then joined to the bulb where the hole has been made. This is called the tubulating process and the result is to be seen in Fig. 7. This tube is about 1⅞ inches in length and is cut with many others from a long one in a separate department. The tubulated bulb, neck down, is next placed in a blowing off machine which cuts the neck to the proper length and with a pressure of air which is passed down through the tube and bulb makes a flare at the end of the neck (Fig. 8).

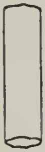


FIG. 1.

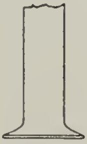


FIG. 2.

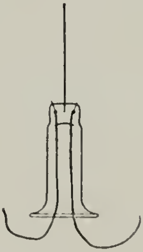


FIG. 3.

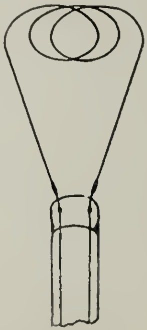


FIG. 4.

We are now ready to place the mount (Fig. 4), which we left a few minutes ago, within the bulb (Fig. 8), sealing them together.

Sealing-in.—The mount (Fig. 4) is placed upon a machine and the bulb (Fig. 8) is set over it. The former is adjusted so that the flange on the stem properly meets the flare of the bulb.

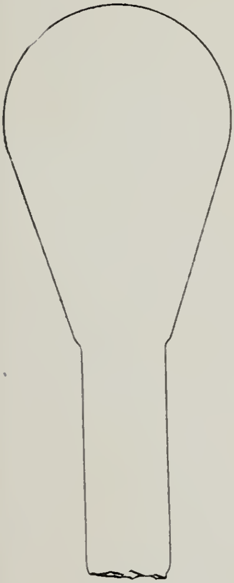


FIG. 5.

FIG. 6.

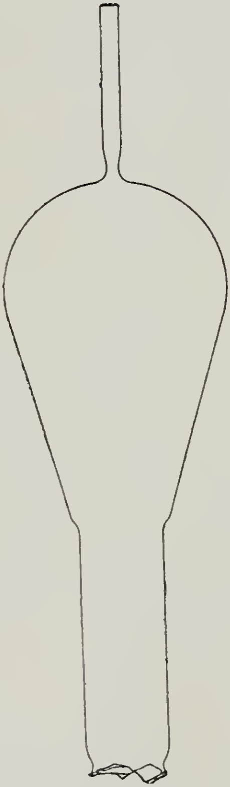


FIG. 7.

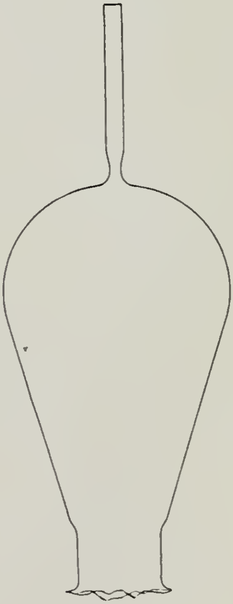


FIG. 8.

The stem and bulb in this position are put into what is known as the first fire, to be warmed up. They then go into the final fire and the glass of the flange and the flare of the bulb are hermetically sealed together (Fig. 9). The lamp is now removed from the machine and a pair of pliers are inserted into the stem centring the filament and forming a ridge on the outside of the seal, making it more secure and creating an anchorage for the cement used in basing. The lamp is now annealed and afterwards inspected.

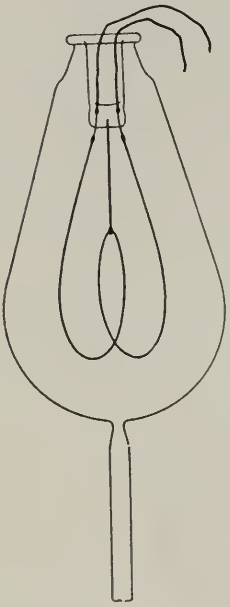


FIG. 9.

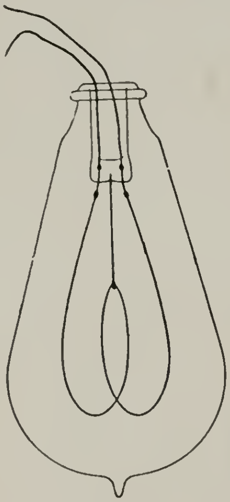


FIG. 10.

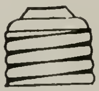


FIG. 11.

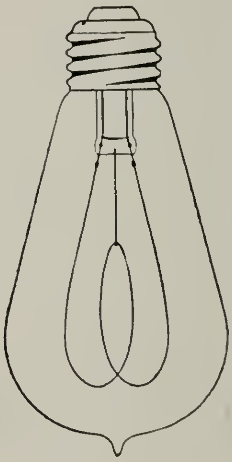


FIG. 12.

Exhausting.—Producing a vacuum within the lamp and sealing or tipping the tube through which the exhausting takes place is the next operation. First, the inside of the top tube is painted with a phosphorus preparation. The lamp is then heated in an extremely hot flame to drive the gas from its sides. Next it is connected to a preliminary pump and the air is fairly well exhausted. Following this it is attached to a second pump which has an ability to produce a higher vacuum and practically all the air is extracted. While on the second pump the lamp is lighted. The pumps are shut off and the gas flame is directed against the tube heating the phosphorus matter which gives off a gas which combines with the residual gases in the bulb, forming a solid precipitate so small that it cannot be seen. At the same time the exhaust tube is fused off a short distance below the bottom of the bulb, leaving the tip which is seen on the majority of lamps (Fig. 10), and the current is shut off from the lamp. The lamp is now inspected for spotted filament, vacuum, and all mechanical and electrical defects which could possibly have taken place up to this point. It is then ready for the photometer room, that is, to be tested to determine the voltage at which it will give the candlepower for which it is manufactured. Upon this being ascertained it is placed in a tray with similar lamps and left in a certain section of the factory until the tray becomes full, when it is put into stock. Ordinary 2 to 24 candlepower lamps are sorted fifty to a tray; with larger sizes there are naturally less.

Finishing.—When an order is received lamps of proper candlepower voltage and current are taken from the stock room and again tested for vacuum. A felt washer and a license label are then placed in the stem. The former keeps the leading-in wires apart and also prevents cement from getting in. The lamp is again tested for spots and for selection by being burned in series. This would readily show if any lamp had become mixed. The next step is the basing. A shellac cement is placed in the base (Fig. 11), which is put over the neck of the lamp, one of the leading-in wires coming out through the centre of the tip of the base. The other leading-in wire protrudes between the lamp and the shell of the base. The lamp is then placed in an oven and the base thoroughly baked. The leading-in wires are then soldered to the base and the lamp is cleaned by having the lower three-quarters of it placed in boiling water containing whiting. It is then dried with paper and the base is cleansed. The lamp is then labelled, tested for vacuum, straight base, proper soldering, cleanliness and all mechanical and electrical defects. If etching is desired it is done at this time. The lamp is also frosted at this stage, label of course not having been put on. Fig. 12 shows a carbon lamp completed. The lamp is now ready for shipment.

Sixty-eight people at least handle a carbon filament incandescent lamp while it is in the process of construction, no two people doing the same kind of work. This does not include the parties having charge of inspections, neither does it mean that only that number of operations are necessary. Some of the help take charge of a lamp while it is going through several steps in the course of completion.

GEM LAMPS.

The chief difference in the manufacturing make-up of the gem lamp compared to a carbon is that the thread of the former is baked in an electric furnace before and after being treated, giving it the appearance and electrical characteristics of a metal.

MANUFACTURE OF TANTALUM LAMPS.

The manufacturing process of the tantalum lamp (Fig. 14) differs from that of the carbon lamp in the following respects:

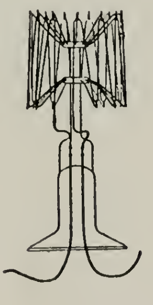


FIG. 13.

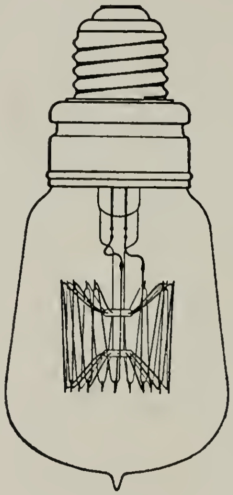


FIG. 14.

The filament, which is drawn from tantalum, a metal, is of very low resistance, and therefore has to be extremely long. It is found convenient to support it upon spiders, attached to a glass tree, which is connected to the stem where the anchor in a carbon lamp is found (Fig. 13). The parts of the leading-in wires composed of platinum do not protrude from the end of the stem, but are sealed therein and are joined to small copper wires with tubed ends, which extend from the stem for an inch or so and into which are inserted the ends of the tantalum filament, a firm connection being made by pressing the tubed copper wires together. No paste is used in making the joint.

MANUFACTURE OF TUNGSTEN LAMPS.

The manufacturing process employed in producing tungsten lamps is similar to that adopted in building carbon illuminants, excepting in the construction of the filament and the mount.

Tungsten is an acid-forming metal, found in the following ores:

Wolframite,—in the form of tungstate of iron and manganese.

Tungstenite or shellite,—in the form of tungstate of calcium.

Scheeletine,—in the form of tungstate of lead.

Wolframine,—in the form of tungstic acid.

Tungsten is also frequently found in tin ores.

The tungsten used in manufacturing lamp filaments is secured, as far as the writer knows, entirely from wolframite, and is received by the lamp manufacturers in this country in the form of tungstic acid, a powder and oxide.

Tungstic acid may be secured by finely grinding wolframite, heating same with hydrochloric acid, which disrupts the tungstate of iron and manganese, forming an oxide of tungsten, and chlorides of iron and manganese which are soluble. The oxide of tungsten and chloride of iron and manganese are washed thoroughly by decantation, that is, by letting it settle and pouring off the liquids. This should be done at least a dozen times. By such a procedure we secure oxide of tungsten and a few minor impurities. This precipitate is dissolved in ammonia, forming ammonium-tungstate, which is filtered free from most of the impurities.

The ammonium-tungstate which has passed through the filter is heated, the ammonia and water evaporating, leaving ammonium-tungstate, which is boiled after nitric acid has been added to it. The ammonium-tungstate, after it has been thoroughly washed with water to entirely eliminate all traces of nitric acid, becomes tungstic acid practically free from other compounds.

The First to Experiment.—Dr. Auer Von Welsbach, who more than twenty years ago brought out the gas mantle bearing his name, commenced previous to 1898 to experiment with osmium for the purpose of employing it as a lamp filament, because of the extremely high temperature to which it could be subjected without vaporizing or losing solidity. The fact became apparent, however, that the scarcity of this article would probably make it impracticable for commercial purposes. Tungsten was therefore substituted, as it could be handled on about the same lines, and the results already secured with osmium would be of great value. At this time Drs. Just and Hanaman, working in conjunction, and Dr. Kuzel also started to experiment with tungsten as an illuminant.

Therefore, several years ago at least three sets of men, working along different lines, were endeavoring to bring out tungsten lamps.

Principal Methods of Manufacturing Tungsten Filaments.—We will take this subject up briefly and in a general way, it being unnecessary to go into details. The chief object is to show that the filament, like that of carbon, is squirted and not drawn from metal.

The Auer process consists of taking tungstic acid, driving practically all of the oxygen from it, bringing it into a state of metallic tungsten, which is mixed with a binder and squirted through delicate diamond dies, into threads.

Drs. Just and Hanaman use the substitution process, which up to a certain point is greatly similar to that employed in making the regular cellulose filament. Practically no change in construction occurs until the treating stage is reached. Then a gas of tungstic compound is used, instead of hydrocarbons.

The Kuzel, or colloid process, consists of treating metallic tungsten with strong boiling acid and alkali, alternately, washing it intermittently with water until converted into a colloid. The colloid is then precipitated, the liquid is drawn off and the residue, consisting of a gelatinous mass, is squirted. Another method of securing colloidal tungsten is to take two tungsten electrodes, place them under water, and allow an electric current to pass from one to the other. Small particles of tungsten are disrupted from the electrodes, passing into the water, forming colloidal tungsten.

Any of the three above methods will result in producing fairly pure tungsten. There is, however, more work to be done, and it is believed that all the parties mentioned herein pursue nearly the same course from this point of manufacture.

The filament having been squirted, it is dried in an oven, after which it is placed in an electric furnace operated at about 2000° C. This readily removes the more volatile parts. It is then taken out of the furnace, and an electric current is passed through it while it is occupying an atmosphere of inert gas. The result is the production of a thread composed of practically pure tungsten.

Mounting Tungsten Filaments.—The method of mounting a tungsten filament differs from that employed with a carbon filament. The platinum tips of the leading-in wires which generally protrude from the stem are entirely sealed therein and are connected to copper wires which extend through the stem into the lamp and are electrically welded to two legs of the filaments.

The filaments in the lamp are supported by anchors attached to a glass tree which is firmly connected to the stem (Fig. 15).

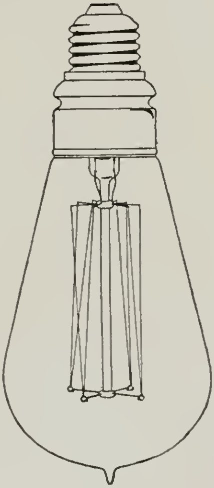


FIG. 15.

PERFORMANCE OF CARBON, TANTALUM, AND TUNGSTEN LAMPS.

From the standpoint of current, candlepower, total watts, and w. p. c., tantalum, tungsten, and metallized carbon filament lamps are less susceptible to changes in electrical pressure than regular carbon lamps. The resistance of the metal and metallized filament increases, whereas that of the regular carbon filament usually decreases with a rise in voltage.

Following will be found tables showing the comparative results upon carbon, gem, tantalum, and tungsten lamps, when they are operated at from 90 to 110 per cent. of their normal voltage:

CHANGE OF RESISTANCE WITH CHANGE OF VOLTAGE

Percentage of voltage to that of normal	Percentage of resistance to that at normal voltage			
	Carbon	Gem	Tantalum	Tungsten
90%	100.16%	98 %	97 %	96 %
95	100.08	98.7	98.5	98
100 (Normal)	100	100	100	100
105	99.91	100.7	101	102
110	99.81	101.6	102.5	104

CHANGE OF CURRENT WITH CHANGE OF VOLTAGE

Percentage of voltage to that of normal	Percentage of current to that at normal voltage			
	Carbon	Gem	Tantalum	Tungsten
90%	90 %	91 %	93 %	93.5%
95	95	96.3	97	97
100 (Normal)	100	100	100	100
105	105	104	103.5	103
110	110	108.25	107	106

VARIATION OF C. P. COMPARED TO VARIATION OF VOLTAGE

Percentage of voltage to that of normal	Percentage of candlepower to that at normal voltage			
	Carbon	Gem	Tantalum	Tungsten
90%	56 %	59.5%	64 %	67 %
95	75	77	80.5	82
100 (Normal)	100	100	100	100
105	131	128.5	123	119
110	168	162	148	141

PERCENTAGE OF CHANGE IN TOTAL WATTS COMPARED TO PERCENTAGE OF CHANGE IN VOLTAGE

Percentage of voltage to that of normal	Percentage of total watts to that at normal			
	Carbon	Gem	Tantalum	Tungsten
90%	81 %	82 %	83.5%	84 %
95	90	91.5	92	92
100 (Normal)	100	100	100	100
105	110.5	109.4	109	108
110	121.5	120.3	117.5	117

WATTS PER CANDLE OF LAMPS

Percentage of voltage to that of normal	Watts per mean horizontal candlepower			
	Carbon	Gem	Tantalum	Tungsten
90%	4.5	3.4	2.73	1.57
95	3.73	3	2.39	1.4
100 (Normal)	3.1	2.5	2.1	1.25
105	2.61	2.19	1.86	1.13
110	2.23	1.85	1.66	1.03

Watts per candle of lamps operated at 90 to 110 per cent. of normal voltage when the m. h. c. p. specific efficiency is: carbon 3.1; gem, 2.5; tantalum, 2.1; and tungsten, 1.25. See table.

In glancing over the tables given in this article, it will be seen that with the exception of resistance, the minimum and maximum points reached in performance when the e. m. f. changes are nearer to that of normal with metal and metallized filament lamps than with those having regular carbon filaments. Whereas, at 90 per cent. of normal voltage, a carbon lamp's resistance is 100.16 per cent. of that secured at normal voltage, that of the gem is 98 per cent., that of the tantalum is 97 per cent., and that of the tungsten is 96 per cent. At 110 per cent. of normal voltage the resistance to that at normal is 99.81 per cent. with a carbon, 101.6 per cent. with a gem, 102.5 per cent. with a tantalum, and 104 per cent. with tungsten lamp.

On account of the different characteristics of the resistance of the carbon, gem, tantalum, and tungsten lamps, their current is naturally affected in such a way, that at 90 per cent. of normal voltage it is reduced 10 per cent. with carbon lamps, 9 per cent. with gem lamps, 7 per cent. with tantalum lamps, and 6½ per cent. with tungsten lamps; and at 110 per cent. of normal voltage, the current of the carbon lamp is increased 10 per cent., of the gem 8.25 per cent., of the tantalum 7 per cent., and of the tungsten 6 per cent.

The resistance of tungsten, tantalum, and gem lamps, being less than that of regular carbon lamps, when operated at a voltage lower than normal, causes their current, as has been shown, to be higher respectively, and their candlepower must necessarily be greater. The carbon lamp gives 56 per cent., the gem 59.5 per cent., the tantalum 64 per cent., and the tungsten 67 per cent. of its rated candlepower, when operated at 90 per cent. of normal voltage, and 168 per cent., 162 per cent., 148 per cent., and 141 per cent. candlepower, respectively, when run at 110 per cent. of correct voltage. This shows that the light delivered by metal and metallized lamps is much less affected than that from regular cellulose filament lamps, by variation of voltage, a fact which has already been mentioned. It is a matter, however, which cannot be brought out too strongly. Therefore, let us once more refer to the table showing variation of candlepower compared to variation of voltage, and note that a drop of 5 per cent. from normal voltage causes a reduction of 25 per cent. in the illumination received from carbon, 23 per cent. in that received from gem, 19½ per cent. in that received from tantalum, and 18 per cent. in that received from tungsten lamps. A rise of the same percentage above normal, causes an addition in candlepower of 31 per cent. with regular carbon, 28.5 per cent. with gem, 23 per cent. with tantalum, and 19 per cent. with tungsten lamps.

The increase in total watts is less with metal and metallized filament lamps than with regular carbon filament lamps, operated above voltage.

The w. p. c. do not vary as much with tantalum, tungsten. and gem lamps as they do with carbon, when the voltage is changeable. Not only are the metal and metallized filament illuminants far more efficient, but their percentage of change in w. p. c. is much less than that of carbon lamps, when run at a fluctuating voltage. When the electrical pressure is unsteady the performance of both the metal filament lamps mentioned herein is certainly most gratifying. The nearer the results obtained at varying voltage comes to that secured at normal, the more the troubles will be diminished of the parties generating and using current for lighting. With every recent development of a new lamp, a marked improvement has taken place in this respect.

Rating of Lamps.—The majority of carbon lamps are designated according to their mean intensity of light in a horizontal direction. Gem, tantalum, and tungsten lamps are rated by their lamp wattage. The valuing of lamps by the average of only a portion of their luminous flux is misleading, unless it is simply the illumination produced thereby which is being considered. In this event, the necessary light may ofttimes be strengthened by the use of reflectors, and the efficiency should be based upon the results obtained from the lamp operated in conjunction with its accessory. As the approximate total wattage of a lamp is always known, and as the effective candlepower of a lamp is often unknown to lamp manufacturers, because of their being unaware of the reflector which will be used in conjunction with the illuminant, it is easy to see why a change in rating has taken place.

Efficiency.—Rated according to their mean horizontal candlepower, the English parliamentary candle being used as a unit,

Designation		1	Carbon				Gem							Tantalum				Meridian Tungsten		Regular Tungsten			
														Direct		60 ~ Alter'g							
C. P.		2	16	16	32	32	16	20	32	40	60	75	100	20	40	20	40	32	48	20	32	48	80
Nominal W. P. C.		3	3.1	3.5	3.1	3.5	2.5	2 5	2.5	2.5	2.5	2.5	2 5	2.0	2.0	2.0	2 0	1.25	1.25	1 25	1.25	1 25	1.25
Actual W. P. C.		4	3.1	3.5	3.1	3 6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.0	2.0	2 0	2.0	1 25	1.25	1 25	1 25	1.25	1.25
Total Watts		5	49 6	56	99.2	114 2	40.	50	80	100	125	187.5	250	40	80	40	80	40	60	25	40	60	100
Hours Useful Life		6	450	830	430	900	450	450	450	460	450	450	450	800	800	450	600	800	800	800	800	800	800
K.W.H. Cons. dur. Useful Life		7	22.3	46.5	42 6	102.7	18.0	22.5	36 0	46.0	56.3	84.4	112.5	32	64.	18.	48.	32.	48.	20	32.	48.	80.
Cost of Lamp		8	.20	.20	.30	.30	.25	.25	.35	.35	45	65	.80	.50	.85	50	.85	1.50	1.75	0 85	1.10	1.40	1.75
Cost of Renewals per 1000 Hrs.		9	.444	.241	.698	.333	.556	.556	.778	.737	1.00	1.444	1 778	.625	1 063	1 111	1 416	1.875	2.188	1 063	1.375	1.75	2.188
Cost of Power per Kilowatt Hour Table of Combined Cost of Power and Lamp Renewals per 1000 Hours	.0050	10	.692	.521	1.194	.904	.756	.806	1.178	1.237	1 625	2.382	3.028	.825	1 463	1.311	1.816	2.075	2.488	1 188	1.575	2.06	2 688
	.0075	11	.816	.661	1.442	1.186	.856	.931	1.378	1.487	1.937	2.850	3.653	.925	1 663	1.411	2.016	2.175	2.638	1 251	1.675	2.20	2.938
	.0100	12	.940	.801	1.690	1.475	.956	1 056	1 578	1.737	2.250	3.319	4.278	1.025	1 863	1.511	2 216	2.275	2.788	1 313	1.775	2.35	3.188
	.0125	13	1.064	.941	1.938	1.760	1.056	1.181	1.778	1.987	2 562	3 788	4.903	1.125	2 063	1.611	2.416	2.375	2.938	1 376	1 875	2.50	3.438
	.0150	14	1.188	1.081	2.186	2.046	1.156	1.306	1 978	2.237	2.875	4.257	5 528	1 225	2.263	1.711	2.616	2.475	3.088	1 438	1.975	2.65	3.688
	.0175	15	1.312	1.221	2.434	2.331	1.256	1 431	2.178	2.487	3.187	4 725	6.153	1.325	2.463	1.811	2.816	2 575	3 238	1 501	2 075	2.80	3.938
	.0200	16	1.436	1.361	2.682	2.617	1.356	1.556	2 378	2.737	3.500	5.194	6.778	1 425	2 663	1.911	3.016	2 675	3.388	1 536	2.175	2 95	4 188
	.0225	17	1.560	1.501	2.930	2.902	1.456	1 681	2.578	2.987	3.812	5.663	7.403	1 525	2.863	2 011	3.216	2 775	3.538	1 626	2.275	3.10	4.438
	.0250	18	1.684	1.641	3.178	3.188	1.556	1 806	2 778	3.237	4.125	6.132	8.028	1 625	3 063	2 111	3 416	2.875	3.688	1 688	2.375	3.25	4.688
	.0275	19	1.808	1.781	3.426	3.473	1.656	1.931	2.978	3.487	4.437	6.600	8.653	1 725	3 263	2.211	3 616	2 975	3.838	1 751	2 475	3.40	4.938
	.0300	20	1.932	1 921	3.674	3.759	1.756	2 056	3.178	3.737	4.750	7.069	9 278	1.825	3 463	2 311	3 816	3.075	3 988	1 813	2.575	3.55	5.188
	.0325	21	2 056	2.061	3.922	4.044	1.856	2.181	3.378	3.987	5.062	7.538	9 903	1 925	3 663	2.411	4 016	3 175	4 138	1 876	2 675	3 70	5.438
	.0350	22	2.180	2.201	4.170	4.330	1.956	2 306	3 578	4.237	5.375	8.007	10.528	2 025	3.863	2 511	4 216	3.275	4.288	1 938	2.775	3.85	5 688
	.0375	23	2.304	2.341	4.418	4.615	2.056	2.431	3.778	4.487	5.687	8.475	11 153	2.125	4 063	2 611	4 416	3 375	4 438	2 001	2 875	4.00	5.938
	.0400	24	2.428	2.481	4.666	4.901	2.156	2.556	3 978	4.737	6 000	8 944	11 778	2 225	4 263	2 711	4 616	3.475	4.588	2 063	2 975	4.15	6 188
	.0425	25	2.552	2.621	4 914	5.186	2 256	2 681	4.178	4.987	6.312	9.413	12.403	2.325	4 463	2 811	4 816	3 575	4 738	2 126	3 075	4 30	6.438
	.0450	26	2.676	2 761	5.162	5.472	2.356	2 806	4.378	5 237	6 625	9.882	13.028	2.425	4.663	2 911	5.016	3 675	4 888	2 188	3 175	4.45	6.688
	.0475	27	2.800	2.901	5.410	5.757	2 456	2 931	4 578	5 487	6.937	10 350	13.653	2 525	4 863	3 011	5 216	3.775	5 038	2 251	3 275	4.60	6.938
	.0500	28	2.924	3.041	5.658	6.043	2.556	3 056	4 778	5.737	7 250	10.819	14.278	2.625	5 063	3.111	5 416	3 875	5 188	2 313	3.375	4 75	7 188
	.0550	29	3.172	3.321	6.154	6.614	2.756	3 306	5 178	6 237	7.875	11.757	15.528	2.825	5.463	3 311	5.816	4 075	5.488	2 438	3.575	5.05	7.688
	.0600	30	3.420	3 601	6.650	7.185	2.956	3 556	5.578	6 737	8.500	12.694	16 778	3 025	5 863	3 511	6 216	4 275	5.788	2 563	3 775	5.35	8 188
	.0650	31	3.668	3.881	7.146	7.756	3.156	3.806	5.978	7 237	9.125	13.632	18.028	3.225	6 263	3.711	6 616	4 475	6 088	2 688	3.975	5.65	8.688
	.0700	32	3 916	4.161	7.642	8 327	3.356	4.056	6.378	7.737	9 750	14 569	19.278	3.425	6 663	3.911	7 016	4 675	6 388	2 813	4.175	5.95	9.188
	.0750	33	4.164	4.441	8 138	8.898	3.556	4.306	6.778	8 237	10 375	15.507	20.528	3 625	7 063	4 111	7 416	4 875	6 688	2 938	4.375	6.25	9 688
	.0800	34	4.412	4.721	8.634	9.469	3.756	4.556	7.178	8 737	11.000	16.444	21.778	3.825	7 463	4 311	7 816	5 075	6 988	3 063	4.575	6.55	10.188
	.0850	35	4.660	5.001	9.130	10.040	3.956	4.806	7.578	9 237	11 625	17 382	23 028	4 025	7 863	4 511	8 216	5 275	7 288	3 188	4.775	6.85	10.688
	.0900	36	4.908	5.281	9.626	10 611	4.156	5.056	7.978	9 737	12 250	18 319	24 278	4 225	8 263	4 711	8.616	5 475	7 588	3 313	4 975	7.15	11.188
	.0950	37	5.156	5.561	10.122	11 182	4 356	5 306	8.378	10.237	12 875	19 257	25.528	4 425	8 663	4 911	9 016	5 675	7 888	3 438	5 175	7 45	11 688
	.1000	38	5.404	5.841	10.618	11.753	4.556	5 556	8 778	10.737	13.500	20.191	26.778	4.625	9 063	5.111	9 416	5 875	8 188	3 563	5 375	7.75	12.188
	.1050	39	5.652	6.121	11 114	12 324	4.756	5.806	9 178	11.237	14.125	21.132	28 028	4.825	9 463	5 311	9 816	6 075	8 488	3 688	5 575	8 05	12 688
	.1100	40	5.900	6.401	11.610	12.895	4.956	6 056	9 578	11.737	14 750	22.069	29 278	5 025	9.863	5 511	10 216	6.275	8 788	3 813	5 775	8.35	13.188
	.1150	41	6.148	6.681	12.106	13.466	5 156	6.306	9.978	12.237	15.375	23 007	30.528	5.225	10 263	5.711	10 616	6 475	9 088	3 938	5.975	8.65	13.688
	.1200	42	6.396	6.961	12.602	14.037	5.356	6.556	10 378	12 737	16.000	23 944	31 778	5.425	10 663	5 911	11 016	6. 675	9.388	4 063	6 175	8 95	14 188
	.1250	43	6.644	7.241	13.098	14.608	5 556	6.806	10.778	13.237	16 625	24.882	33.028	6 625	11.063	6 111	11 416	6 875	9.688	4 188	6.375	9.25	14 688
For each one cent difference in cost of Lamp add or subtract		44	.0222	.0120	.0232	.0111	.0222	.0222	.0222	.0217	.0222	.0222	.0222	0125	0125	.0222	0166	.0125	.0125	0125	0125	0125	.0125
Cost of Renewals per 100 K W H		45	$8.95	$4 31	$7.04	$2 92	$12 39	$11.11	$9.72	$7 37	$8 00	$7 69	$7 12	$15 62	$13.29	$27 78	$17 70	$46 87	$36.46	$42.50	$34.37	$29.17	$21.87

the highest commercial efficiency of carbon lamps of 8 c. p. and over is 3.1 w. p. c. with a useful life of approximately 450 hours; of a gem lamp, 2.5 w. p. c. with equal useful life; of a tantalum lamp, 2 w. p. c. with a useful life of 800 hours on d. c., uncertain on a. c.; of a tungsten lamp, 1.25 w. p. c. with a life of 1000 hours.

Although the operating temperature of the tungsten filament is higher than that of any of the other illuminants mentioned herein, the lamp itself, while in service, is much cooler than the carbon, gem, or tantalum lamp.

Intrinsic Brilliancy of Lamp Filaments.—The candlepower per sq. inch of the filaments of carbon 3.1 w. p. c., gem 2.5 w. p. c., tantalum 2 w. p. c., and tungsten 1.25 w. p. c. lamps is 480, 625, 750, and 1000 respectively.

Quality of Light.—The light of tungsten lamps more closely approaches daylight than that of other illuminants. It naturally follows that tungsten lamps cause colors to retain more nearly their true values than any other artificial light source.

I wish to thank Mr. Frank M. Dorsey, chemist, for assistance in the preparation of this paper, and the Shelby Tungsten Lamp Works for the use of the accompanying table.

SEMIPRECIOUS STONES.

THE chief centre for the manipulation of semiprecious stones in Germany is in the Rhine Province.

Both at Oberstein and Idar an important industry has been created, which had its inception in the cutting and dyeing of native agate, the chief deposits of which are now exhausted. At present imported stones are handled chiefly, these coming principally from England and South America. Although agate only was dressed and colored in the early years of this industry, at present all classes of stones are prepared for market. In this, however, the art consists not only in forming the rough stone, but in giving it color as well. It was first learned that the natural color of agate could be changed by firing, and then that by warming the dressed stones in a solution of sugar or honey, and coating them with various concentrated acids which carbonize the sugar, a color was imparted to the more porous strata, while in the case of agate the impenetrable crystalline strata appeared whiter than before. [Consular Report.]

MECHANICAL AND ENGINEERING SECTION

(*Stated meeting held Thursday, December* 3, 1908.)

LIQUID-EXTRACTING INDUSTRIES AND THE DEVELOPMENT OF PRESSES EMPLOYED THEREIN.

BY

HOMER A. HERR.

THE art of liquid extracting, in its broad sense, embraces every industry where solids and liquids of whatever class or nature present-day commercialism requires shall be separated.

The paint used in beautifying our homes and preserving our structures from the hand of decay; the condiments that feed the King, the Epicurean and the Plebe; the wines, which are alike sustaining and degrading in their use and abuse respectively; the paper which is so important an element in modern life, reflecting and transmitting the intellectual activities of the world's thinkers and doers; the sweetmeats, which, regardless of their abuse, are indispensable to our life in its spring, summer, autumn and winter; the glue which enters into the manufacture of myriads of domestic articles of necessity; the fertilizer which enriches the soil that nature may give a bounteous yield to the seeds it nourishes and the landscape may be the more beautiful in its carpet of velvet and green;—all would be practically unattainable without some form of liquid extracting. These are, however, but a few of the labors accomplished by the art of the liquid extractor.

It is manifestly evident that an industry that is so co-related with our very existence and almost co-extensive with the industrial activity of the period, when embracing its many branches, is of vast human interest, of great economic moment, of large financial importance and engagement.

Before discussing the industries effected by the present methods of liquid extracting or of the means employed in former and older days, it appeals to me as a fundamentally desirable introduction to this subject, elementary though it be, to briefly refer to the anatomical relation between liquids and their co-related solids. While it would be aside from my subject to enter to any extent into the science of vital phenomena, yet cell life in its beautiful theories and interesting facts explains the primary and physical relation between solids or the residuum of commerce and the liquids, or the oil and juice of our marts.

The literal meaning of the word cell is a hut, a cave or a small room, and every room must have a wall else no room could exist, no cell be possible.

A cell, therefore, is the fundamental form of all animal and vegetable organization into which all organized tissue is resolved.

In Nature's great design there are many classes of cells, but so far as cell life has to do with this subject it concerns the fat cells in animal life and the liquid-containing cells in vegetable life, regardless of the character of the liquid therein contained.

It will be understood that according to the cell theory the bodies of all animals and plants consist, therefore, of either a cell or a number of cells, and their products, and a cell will multiply itself by a division of its contents and the secretion of a wall about and around each portion. These capsulated elemental forms of structure or tissue contain within their walls the liquids that it is the problem of the liquid extractor to separate from the solid substance forming the wall itself. These cells are of microscopic size, countless millions in number and of infinite variety of form.

Now, just as immutable as are the laws which govern the development and formation of these cells or crystals, so fixed and unchangeable are the conditions, so immutable are the laws which must be invoked and obeyed by the liquid extractor in whatever art it is sought to separate the walls of the cells from their contained liquid, and it is evident that, inasmuch as all vegetable and animal matter is a mass of cells of substantially the same physical characteristics in like substances, they require similar treatment and similar conditions to rupture the walls and liberate the contained juices in like arts.

The evolution of an important art has its history. This history becomes interesting in proportion to the scope and human interest in the art, whether this interest is commercial, scientific or sentimental.

The art of separating liquids from solids is as old as the human race, older than history itself. The ancient Assyrians had their wine press; and who can tell but that the lost arts of the ancient Egyptians may have included in their sepulchre some brilliant mechanical scheme employed in that early day to provide wine and drink for the feasts of the Pharaohs.

On the liquid extracting of the early periods, however, I will not dwell, but it is doubtful if any of the great technical industries have shown so little of a steady evolutionary progress as have the liquid-extracting industries in one hundred years. The methods and means employed to-day are almost the same that were employed one hundred years ago.

The law prescribes the amount of liquid, under the term "moisture," which may remain in solids and the solids be thus sold. This amount of moisture is 8 per cent. That is to say, for every ton of material that is sold in a condition of commercial dryness the seller is entitled to pay for 174 pounds of water or liquid. Nature and the law seem to have a mutual understanding, for should a marketable product be sold with 4 per cent. of moisture it will speedily absorb an amount from the atmosphere bringing it up to the legal commercial dryness, 8 per cent. This, of course, does not apply to oils, fats or greases, but moisture in the form of water.

Water is very common, a very universal liquid. It exists everywhere and is found in every animal and vegetable entity during the chemical change we call growth or development. It therefore becomes an important compound with which the liquid extractor has to deal.

In a material having a higher percentage of moisture than 8 per cent. it will be necessary to get rid of this excess. The general art of carrying on this moisture elimination embraces many industries, employs millions of dollars of capital and thousands of laborers. Some of our ablest scientists, most skilful chemists and most accomplished and ingenious engineers are employed by or associated with the many different industries which contribute and represent the liquid-extracting industries of the nation and the world. Industries yet unborn will reap fortunes in the not distant future by association with some art that will be utilizing valuable liquid products now going to waste, industries which have for their base the refuse of our civilization, but will prove to be some of Nature's hidden treasure chests and employ the art of the liquid extractor as the "Open Sesame" for securing the golden contents.

Let us see what the modern liquid extractor has to do.

Original per cent. water.	Pounds of water per ton dried material.	Original per cent. water.	Pounds of water per ton dried material.	Original per cent. water.	Pounds of water per ton dried material.	Original per cent. water.	Pounds of water per ton dried material.	Original per cent. water.	Pounds of water per ton dried material.
1	20	21	532	41	1390	61	3128	81	8526
2	41	22	564	42	1442	62	3263	82	9111
3	62	23	598	43	1509	63	3405	83	9765
4	83	24	632	44	1571	64	3555	84	10500
5	105	25	667	45	1636	65	3714	85	11333
6	128	26	703	46	1704	66	3881	86	12285
7	151	27	740	47	1774	67	4061	87	13384
8	174	28	778	48	1846	68	4250	88	14666
9	198	29	818	49	1921	69	4452	89	16181
10	222	30	857	50	2000	70	4667	90	18000
11	247	31	898	51	2082	71	4896	91	20222
12	273	32	941	52	2167	72	5143	92	23000
13	299	33	985	53	2288	73	5407	93	26571
14	326	34	1030	54	2348	74	5692	94	31333
15	353	35	1077	55	2444	75	6000	95	38000
16	381	36	1125	56	2545	76	6333	96	48000
17	409	37	1174	57	2651	77	6696	97	64666
18	439	38	1226	58	2762	78	7091	98	98000
19	469	39	1279	59	2878	79	7524	99	198000
20	500	40	1333	60	3000	80	8000		

By a reference to this table it will be seen that to get one ton of dried material that originally carried 65 per cent. of moisture, it was necessary for the liquid extractor to expel 3714–174 (8 per cent.) or 3450 pounds of water or moisture. If the liquid extracted was oils by high pressure presses it is possible to reduce this percentage to as low as 6 per cent. in the residuum, which would give 3714–83 pounds or 3631 pounds oil per ton of residue oil cake, allowing it to contain 65 per cent. This residuum after attrition would absorb moisture from the atmosphere to the amount of 83 pounds or more per ton, depending on atmospheric conditions.

The limit of time at my command will not more than permit a slight sketch of the more important industries in which the liquid extractor is engaged, and after an understanding of the scope of a few of these industries and the relation that they sustain to the wealth of our nation and the world, and the wasteful, rule of thumb, empirical and antiquated methods under which they are operated, by considering the present mechanical methods they employ. I propose to introduce to you a machine which reduces the entire art of the liquid extractor to an exact science, a new mechanism, *basic* and fundamental, a machine that spans a century of progress and relieves the liquid-extracting industries from the annoyance of present mechanisms and does not introduce new troubles.

Of all the varied industries forming the business of expressing liquids from solids none is of greater importance than the

VEGETABLE OILS.

These oils are in weight from 32 per cent. in the flaxseed to 70 per cent. in the castor bean of the entire seed and cover a wide and important range of industrial activity.

The peanut, olive, poppy, linseed, cottonseed, castor bean, sesame and paten nut all require substantially the same treatment for extracting of their respective oils from their respective oil cells.

This process is almost the same in all of them at the present time. Before going into a description of the mechanical means for obtaining these oils, it would seem a slight review of the more important of these industries would be of interest.

The most important industry among the vegetable oil industries is the cotton seed. Time will not permit me to dwell on the early doings in this industry, and it is of sufficient importance for us to know that it is to-day one of the most important industries of the United States. From being but a short time ago but an incubus that cotton operators did not know what to do with, it has become one of the great wealth producers of the nation.

There are grown in the United States about 13,000,000 bales of cotton annually, each bale weighing 500 pounds, which amounts to six billion, five hundred million (6,500,000,000) pounds of cotton. For every pound of cotton there are 3 pounds of seed, giving a yield of 19,500,000,000 pounds of seed, valued at about $200,000,000.

There are about 800 cotton oil mills in the United States which are engaged in crushing and pressing this mountain of seed for its oil, aside from that used for planting purposes.

It is estimated that there are 300,000 barrels of this oil used in Chicago for making oil lard, 200,000 in St. Louis and Kansas City, and Holland uses 250,000 barrels annually for olive oil. There is scarcely a restaurant in London, Paris or Berlin that does not use cotton oil on its tables under the name salad oil for the old Lucca product.

The linseed oil industry is also an industry of large proportions. The treatment of the seed of the flax plant from which linseed oil is obtained is the same the cotton seed. This is likewise true of the castor bean and other seeds I need not name.

The process of treating seeds for their oils broadly is: first, perfect trituration, then heating and then pressing while hot.

THE FISH OIL INDUSTRY.

A century ago it was part of the duties of the farmers along the Atlantic coast to devote some weeks in each year to catching menhaden fish (a species of the herring family) for fertilizer.

Finally they discovered that these fish were rich in oil, which they obtained and used for painting, leather dressing and other purposes. The following is the manner in which they would get the oil: They would take a few hogsheads and partly fill them with fish and water, placing boards with stones on them on the fish. The fish would disintegrate by putrefaction and the oil would float to the surface, after which they would skim it off. It would take several weeks to treat one hogshead of fish.

This method was succeeded by providing kettles in which the fish were boiled to facilitate the breaking of the oil cells and then putting the boiled fish in the casks. In 1830 this became an industry of some importance.

In 1841 the first steam cooker was built at Portsmouth, R. I. In 1850 Daniel Wells built the first fish oil factory on Shelter Island. He handled about 3,000,000 fish per annum.

The first press was built by Charles Tuthill, at Wells's factory, in 1856. This worked so satisfactorily that soon factories commenced to develop rapidly. In 1858 hydraulic presses were first used in this industry.

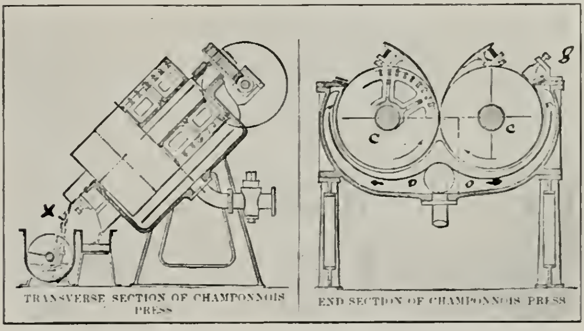
In 1876 floating factories were introduced. These consisted of presses, cooking tanks and boilers mounted on steamers, sail vessels or scows, and they would follow the movements of the fish.

The fish oil business continued to expand until it reached high water-mark in 1884, when 858,592,691 fish were caught, yielding about 4,000,000 gallons of fish oil and about 80,000 tons of tankage.

The average catch of fish in the past 30 years was about 500,000,000 annually. In 1902 about 900,000,000 fish were caught.

Among the many different methods for extracting oil from fish was the process employing fumes of benzin, naphtha and also bisulphide of carbon. When these are brought in contact with the fish in airtight chambers they absorb the oil, which is subsequently recovered by evaporation. This method has been abandoned, not only for fish oil but for nearly all purposes for oil extraction.

FIG. 1.



TRANSVERSE SECTION OF CHAMPONNOIS PRESS

END SECTION OF CHAMPONNOIS PRESS

In 1858 the Ocean Oil & Guano Co. of Southold, N. Y., used a steam cooker similar to the continuous cookers now in use.

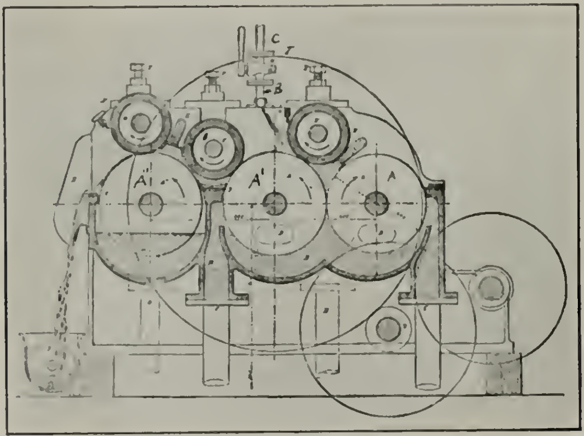
This cooker consists of a steel shell 20 ft. to 30 ft. long. The material is carried along the barrel of the cooker and is broken up by radial arms carried by the hollow shaft which is charged with steam at 80 pounds pressure; from the cooker it goes to the press. It is good practice in this art to allow the fish to remain in a vessel for a few hours after cooking to permit the drawing therefrom of a good per cent. of the oil (as much as 60 per cent. of the oil can be obtained in this way), and then finish the extraction of the oil by pressure.

Screw presses of all classes for fish oil extraction are not efficient. They do not effect a satisfactory extraction of the oil and the fish tankage is consequently of less value, as oil is not a fertilizer.

Under ordinary conditions about 8 per cent. of oil remains in the fish, but with such conditions as obtain in a hydraulic press which I will presently describe, this can be reduced to 5 per cent. if not less.

It is probable that no application of the mechanical powers can boast of such antiquity as the press. The form in which it was first used is lost in antiquity and it is indeed doubtful if any of the arts has shown so little progress as the press, broadly considered, by which the wine and oil, so early recorded among the wealth of nations, were extracted.

FIG. 2.



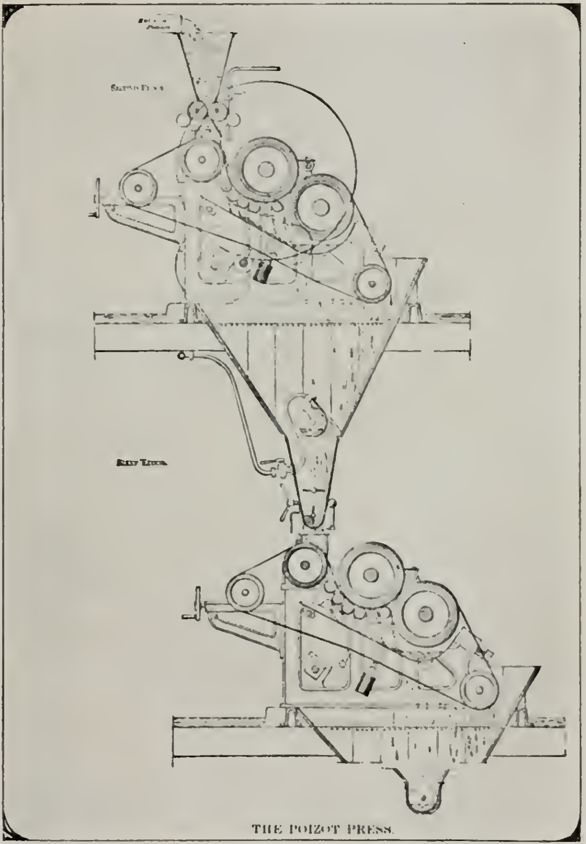
Lebee's press.

The crushing and pressing of vegetable seeds for oil was first introduced into England in the eighteenth century. The Dutch had long since expressed oil from flaxseed by means of plates pressed together by wedges, which were operated by falling weights in the manner of stamp mills.

Ofttimes an artist becomes an historian unwittingly and intuitively and thus fills a gap in the transmission of useful and accurate knowledge to the generations that succeed him. Where the spirit of a period is intensely practical and the conditions of an industry are primitive and empirical, literature of a technical character touching such industry does not exist; thus sometimes does the painter or the poet become the recorder of industrial evolution or mechanical progress.

David Teniers, the celebrated artist, painted a picture in 1623 of an oil mill as above described. This picture is now in possession of Earl Cowper of England and gives an accurate view of one of these old and early mills. Some of these mills still exist in Hull and in Holland. The principle embodied in these early mills is a very excellent one—the wedge.

FIG. 3.



THE POIZOT PRESS.

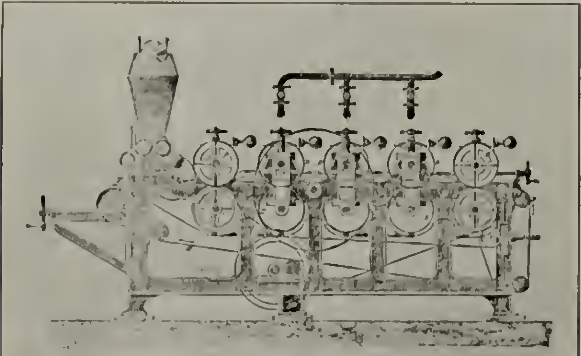
Abrasive action in a liquid-extracting press destroys in many materials the value of the residuum. This is particularly true of substances rich in protein, such as brewers' grains, beet sugar pulp, distillers' slops; in fact of all substances where the material of value is the solids and not the liquids and in many substances where both the solids and liquids are valuable.

Where an abrasive action is employed in the separation of the liquids from the solids, the oil or the liquid becomes heavily impregnated with residuum, and if it is desirable to separate these solids or to purify these liquids, it is a matter of additional expense.

Liquid-extracting machines of to-day are of four general classes:

1. The roller press, including all machines which have rotating cylinders and metallic belts.
2. Screw machines, including all machines which have a screw action or a twisting of the mass of material under treatment.
3. Centrifugal machines, or machines having a hollow perforated rotary cylinder in which a saturated substance can be placed; a rapid rotation of the cylinder forces the fluid through the holes by radial or centrifugal action.

FIG. 4.



SOCIN'S CONTINUOUS PRESS.

4. The hydraulic press, or where hydraulic pressure is employed under the principle of relative velocities.

There are many modifications of the screw and roller presses that need not be considered. There are few in use and they are not practical for the purpose. We shall now consider these machines in the order stated.

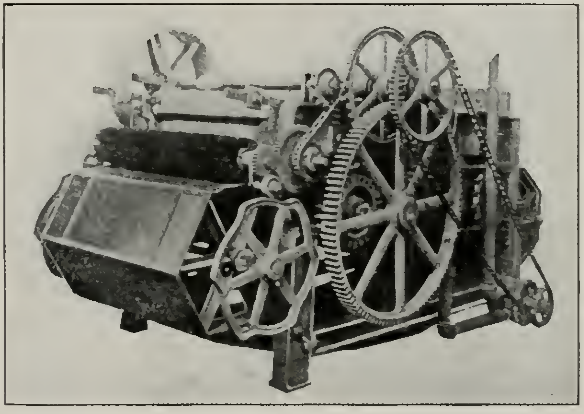
First, the roller press, its merits and its weaknesses:

These machines may be subdivided into two distinct classes and some modifications:

Roller machines, in the manufacture of cane sugar, where the cane is passed between ponderous rolls. Some of these machines are of such dimensions as to require 1000 horse power to operate them. They are well known and I shall not dwell further upon them except to say that they are at present extensively employed in the cane sugar industry, but I prophesy that within moderate time limit they will be succeeded by other better and more economical methods and other and more efficient machines.

The evolution of an art, the evolution of an industry, is sometimes based on knowledge, sometimes on caprice, but nearly always on tests, trials and experiment.

FIG. 5.



Louisville and Kutztown presses.

During the early years of making sugar from beets, presses were employed to extract the sugar juices from the beets direct, the juices were then treated to recover the sugars from the foreign substances therewith contained.

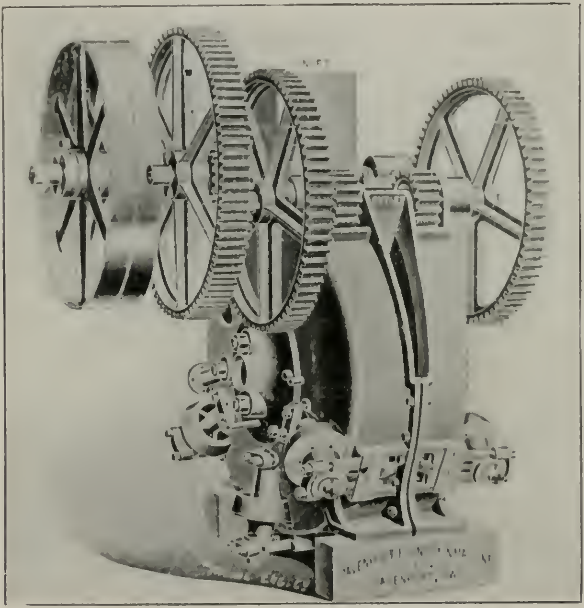
To-day beet sugars are separated from their foreign companions by the diffusion process. This process is based on the phenomenon of osmosis, which occurs between the water and the sugar juices. That is, the water enters the cellular tissues of the beets and drives out the sugar liquid. This gives a purer juice than was possible under the above primitive system of beet-sugar manufacture; and now instead of employing presses to drive the sugar liquids from their cells in the beet cossettes, the presses are employed to drive the water from these cells. after it has driven the sugar juices therefrom.

Now let us consider some of these machines briefly.

CHAMPONNOIS PRESS.

This is in fact a roller press and consists of two rollers sunk into the frame of the apparatus and revolving in opposite directions. The cylinders are covered with a spiral wrapping of triangular wire. The pulp is forced into the lower part of the press (Fig. 1) by a pump and on both sides of the open space o,o, and between the rollers. The juice passes through the spaces between the wire wrapping on the peripheries of the rollers and flows from the machine at X. The roller pulp is scraped from the cylinders by two blades and falls into a receptacle.

FIG. 6.



The Davenport machine.

LEBEE'S PRESS.

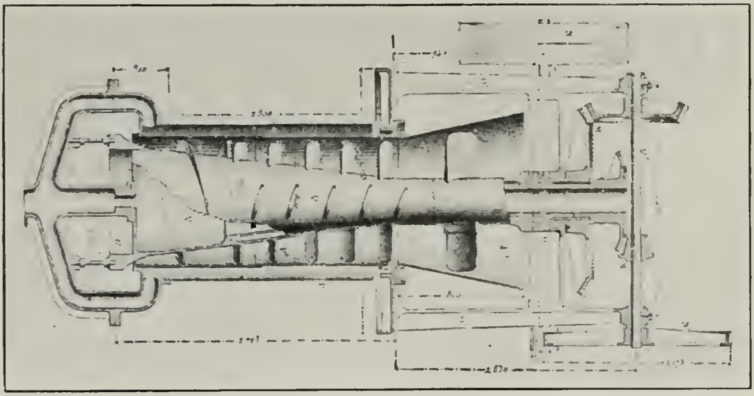
This press (Fig. 2) was claimed to combine the advantages of the Champonnois and some others. At one time it was popular; it is not now used. The pulp is forced into the chamber at B, through the pipe C. The cylinders A,A then press the pulp which continues moving forward under the cylinders F and A′, thence between A′, 1, M and A″ and finally to exit. The juice flows from the pipes D and O to exit. Each cylinder has about 5000 spiral blades, the equivalents of the spiral wire wrappings of the Champonnois press.

POIZOT PRESS.

This press is not much used; a few are in operation in France, and thirty years ago it had some friends. They are nearly all dead, either to the world or to the machine.

It consists (Fig. 3) of a series of cylinders or rollers and an endless belt moving over and around a series of cylinders. The material passes between the cylinder and the belt. The belt being perforated forces the liquid there through. A cleaner is carried by the machine which scrapes the residuum from the large cylinders.

FIG. 7.



The Bergreen screw press.

These machines were mounted in pairs on two floors, the lower being an exact duplicate of the upper one.

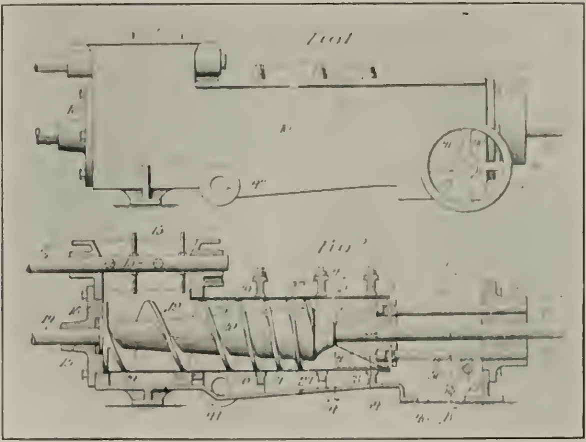
SOCIN'S PRESS.

This machine (Fig. 4) is but a modification of the Poizot. It consists of the same elements, that is, an endless perforated belt and a series of rollers. The material passes between the rollers and the belt, the pressure thereby created forcing the liquid through the perforations of the said belt.

The above roller machines embody the exact principles of all roller machines now made in this country, and in fact the present roller machines are almost exact duplicates in every element of either the Lebee, Champonnois, Poizot, Socin or Collette, just as nearly every screw machine is a resurrected DuJardin used thirty-five years ago in the beet-sugar industry in Germany and France.

The machines just described are all substantially obsolete. Occasionally they reappear in a new dress but the form is the same. The new press with its ancient form takes its final rest in the scrap heap as its ancestors did before it.

FIG. 8.



The Vernstein machine.

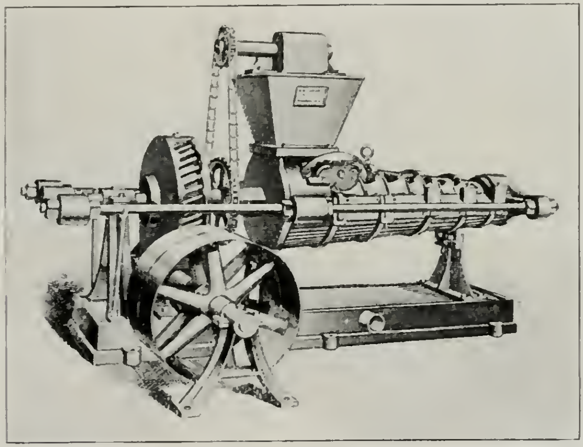
LOUISVILLE AND KUTZTOWN PRESSES.

These machines (Fig. 5) are the same in all their elements as the ones I have briefly described. They consist of a series of pressing rollers, a perforated metal cloth or fabric and a cleaner, with means to actuate the parts, but they are by no means as effective a press as the Poizot, and in due course they will no doubt find the efficiency of their successors will make life burdensome.

The Davenport machine has some structural novelty as a roller press. It consists (Fig. 6) of two inclined discs, whose axes are upwardly inclined. The upper parts of their adjacent sides are at all times wider apart than the lower and as they rotate they draw the material downward to the narrow adjacent lateral faces and force some moisture from the material thus treated.

I will not dwell on other machines of the roller class; they will appear and disappear as they have done for fifty years, but none of them can hold its market, none of them is correct in principle, and they are all on the same principle. They fail in this: the object of liquid extracting is to express liquids from solids so that the solids may be sold on the open market on a basis of 8 per cent. moisture. To do this so that it can be made commercially profitable mechanical pressure must extract the moisture to as low a minimum as possible.

FIG. 9.

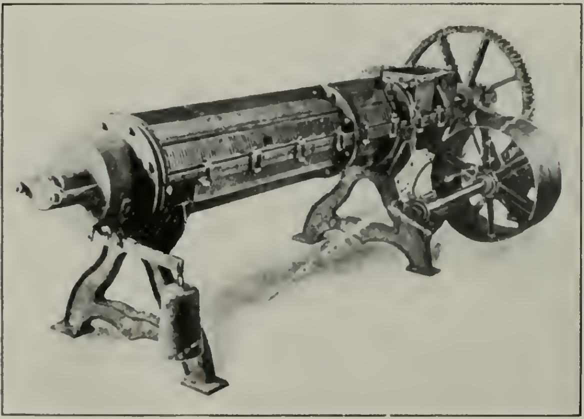


The Lafferty machine.

With these presses it is scarcely possible to reduce the moisture below 65 to 55 per cent. Now a material carrying 65 per cent. of moisture must have 57 per cent. of this moisture evaporated before it can be sold or before disintegration will cease chemically. This means that for every ton of material dried for the market 2650 pounds of water will have to be evaporated by a mechanical dryer, and as it requires about one pound of ordinary mine run coal to evaporate seven pounds of water under favorable conditions, it follows that 2650 pounds of water in a boiler will be evaporated by 380 pounds of coal, but in a steam dryer the value of coal is impaired fully 50 per cent., therefore, when steam dryers are used 2650 pounds of water will require 760 pounds of coal, and with coal at $4.50 per ton, it will cost about $1.50 for coal to evaporate the moisture from the material as it comes from a press 65 per cent. moist for every ton of dried material.

Now we will assume that this was a wet grain material and that the product was ten ton of dried grain daily. There would be a cost for coal alone of $15 per day, a large percentage of which could be saved by an efficient press.

FIG. 1c.



The Guy and Smith machine.

But there is another and equally great loss occasioned by all these roller machines, and wherever you see such a machine in operation you will find the following to be a true condition: The action of these roller machines is harsh and abrasive, they mutilate, they rub the material they press, and this rubbing, this mutilation forces the gluten or protein away with the liquids. Dried grains treated in a roller machine have the most nutritious part carried away with the water and it cannot be avoided. It would be a profitable contract to have the waste occasioned by a roller machine saved and conserved by a means that can do so for as small a volume of material as 500 bushels daily.

SCREW MACHINES.

The principle of the screw has been employed in many slightly modified ways in presses for liquid extracting. These devices are very similar in construction. They consist of a tapered screw in a tapered chamber. The chamber is built in various ways and is usually from 8 to 12 feet long.

In beet-sugar mills the Bergreen pattern of screw press (Fig. 7) is used extensively for expressing the water from the cossettes after they come from the diffusion batteries. It consists of an iron plate cylinder P, which encloses another P^2 containing rectangular apertures and surrounded by a hopper P^3, in the interior of which revolve two superimposed truncated cones Q and Q.′ The latter of these, Q′, carries spirally arranged arms which are so arranged as to compress the slices and push them toward the bottom. On a line with this the lower cone Q revolves in an opposite direction. The slices, pressed, pass through an annular orifice whose diameter is regulated by a ring q and screw q′.

Beet-sugar pulp is about 95 per cent. moist. That is, for every ton of dried pulp you must get rid of 38.000 pounds of water, or 19 tons. These presses cannot reduce the moisture to below 80 per cent. This still leaves 8000 pounds of water to be handled by the dryer, less the legal allowance.

The pulp is valuable as a food for cattle and they thrive on it. As an idea of the great demand for an efficient machine I will give you facts as to the development of the beet-sugar industry in this country and abroad.

This industry had its birth in 1867, but slow progress was made for many years—so slow that in 1892, only sixteen years ago, but six factories were in operation and their combined output was only about 28,000.000 pounds. Now there are sixty-five factories in operation in the United States and they produce about 500,000 short tons of sugar with a value of almost $50,000,000.

The Department of Agriculture at Washington has encouraged the growth of sugar beets, and at its experimental stations is producing a very high grade of beet seed. So high is this grade of seed that tests show that they contain as high as 18.18 and sometimes 20 per cent. sugar.

There are in France 350 sugar factories. All these factories make 1,200,000 tons of sugar, using 8,700,000 tons of beets. In France they obtain about 12 per cent. sugar.

VERNSTEIN MACHINE.

Fig. 8 shows a vertical, longitudinal, and side elevation of a screw press with a conical core and spiral annular flanges with varying pitches. Fundamentally it does not differ from the beet-sugar machine of Bergreen used in the DuJardin's beet-sugar diffusion battery mills forty years ago. The taper plug in this machine, supported by rods and operated by a rack and pinion, has its equivalent and almost identical structure in the ring plug in the Bergreen machine.

LAFFERTY MACHINE.

This machine (Fig. 9) has a solid core with circumferential spiral grooves decreasing in diameter toward the discharge end. In this respect it differs from the machines described. The discharge part is substantially the same.

GUY AND SMITH MACHINE.

This machine comprises a cylinder with a core having circumferential spiral flanges with varying pitches (Fig. 10). It differs in having circumferential slots to permit the liquid to pass from the press chamber.

There are other machines made on substantially the same lines as the above. Some carry longitudinal slots to permit the discharge of the material, others have distinguishing features that differentiate their structure specifically, but specifically only. The fundamental principle and the specific, indeed, is almost the same in all these machines. In all of them the material is fed into the hopper at one end and the screw rotates slowly, about two revolutions per minute. The pitch of the thread (spiral) varies, contracting towards the discharge end of the machine. The density of the material in the chamber gradually increases as the material is forced to the end of smaller area and the liquid passes out in slightly differing ways already described.

The same weaknesses that attend the use of the roller machines are found in these screw presses. They abrade and abuse the material, but even for material for which they are suited they are no more uniform in results than roller machines and will not expel much moisture with any degree of reliability.

CENTRIFUGAL MACHINES.

I do not propose to make more than a reference to centrifugal machines. These machines are used in sugar manufacture to separate the sugar crystals from the boiled syrups which contain them, also in other arts. In the manufacture of beet sugar we first slice the beets, then put these slices through the diffusion batteries, then reduce the juices by evaporation to get the sugar crystals by methods that need not concern us here. The syrups are now put through the centrifugal and the juices are thrown by radial action through the perforations in the wall of the centrifugal cylinder. These cylinders rotate from 800 to 1700 revolutions per minute. The perimeter should travel from five to seven miles per minute. The separating of the juices from the sugar crystals at this great speed is very complete and with first charges speedy. The rotating machine is stopped to unload the sugar remaining in the basket. There are many thousands of these machines in use. While their efficiency as extractors is far in advance of screw or roller machines, they are yet highly imperfect mechanisms and a very large fortune awaits the man who can perfect centrifugals beyond reasonable need for improvement.

In the manufacture of sugar from cane we have first the juice extraction; second, the juice clarification, usually done by a filler press; third, juice evaporation; fourth, syrup production; fifth, syrup concentration; and then sugar production finally by separating the crystals from the syrup by centrifugals. Centrifugals are also used extensively in other industries, but we can dwell on them no longer.

In the machines I have considered for liquid extracting there are inherent weaknesses, faults and objections that are co-existing with the structural principles of the machines themselves. I have directed attention to some of these faults and weaknesses. For high-pressure work these machines have been or are being abandoned. Occasionally a new press appears for low-pressure service in either the screw or roller type, but like those previously designed it lacks in efficiency and soon passes out of use.

Liquid extracting should be an exact science. We should be able to predetermine results, not guess at them. When we have a manufacturing plant that is based on an extraction of 50 per cent. moisture and our dryers are designed to handle material of that per cent. moisture, we do not want to have to treat a 65 per cent. material one hour and a 50 per cent. the next, and possibly 60 per cent. the next, but that is exactly the condition that obtains at present where screw or roller presses are employed.

THE HYDRAULIC PRESS.

The hydraulic press was invented by Joseph Bramah in 1796. This machine has been the most reliable and, indeed, the only reliable ever since, in every application where power and reliability are wanted or needed. Our subject, however, limits us to considering the hydraulic press in liquid extracting.

Hydraulic presses are based on the principle of relative velocities, the underlying principle of many machines. The power of the hydraulic press is established by the relative areas of the piston which pumps the water and the piston (called the ram of the press) which directly moves the load.

Three hundred and thirty years ago Fontana raised an obelisk in Rome with 40 capstans, worked by 960 men and 75 horses; 46 years ago Le Bas raised the Luxor obelisk at Paris with 10 capstans, worked by 480 men; 24 years ago Mr. Dixon raised Cleopatra's Needle in London with 4 hydraulic jacks and 4 men. This gives a slight idea of the power of a hydraulic machine.

Water is almost incompressible but not absolutely. This diminution of volume for water is $^1/_{20,000}$ of its total bulk for a change of pressure of one atmosphere or one-seventieth ($^1/_{70}$) of its volume for a pressure such as we find in hydraulic presses.

A screw will sometimes give 30 per cent. of the energy put into it. Ofttimes it will not give more than 15 per cent. A differential pulley block may give 40 per cent. A hydraulic press will give 90 per cent. This gives us a relative idea of the value of a hydraulic press as compared with the screw, based on tests and recognized facts.

In the early employment of hydraulic presses for liquid extracting they were often operated in pairs and consisted of two stationary plungers and movable basins, having lateral and bottom perforations. The liquid was discharged from the spout in the basin as the basin moved upward against the bottom of the plunger. This was a very expensive and slow method of getting juices and was succeeded by the press cheese of to-day. This press cheese consists of a slatted frame on which a cloth is laid; the material under pressure is placed on the cloth and folded in its four corners inwardly, the corners covering the material. The loaded frames or racks, as they are called, are then piled on top of each other for the press load and pressure is applied.

While the ability to produce a known and desired pressure is substantially the exclusive virtue of the hydraulic press, yet in its practical application to the liquid-extracting industries it has drawbacks and disadvantages. These drawbacks, these disadvantages have been on the score of economy. Nevertheless, regardless of this operating expense, it is estimated that there are over 20,000 hydraulic presses engaged in these liquid and pressing industries in the United States to-day. All other presses combined have but a fraction of this number. These drawbacks, weaknesses and disadvantages have led to considerable activity among inventors, and we will consider a few.

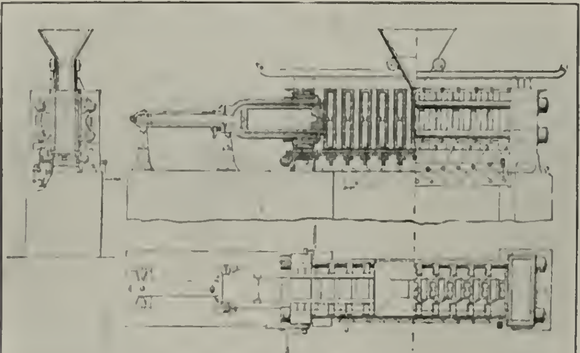
It is the practice in high-pressure liquid-extracting vegetable oil work to first heat the meal, after grinding and thoroughly triturating the seed, by heaters specially designed for this purpose.

The meal is then formed into cakes and placed in the press, one on top of the other, as already described. All this involves labor. In low-pressure work, that is, in the machines where the pressure is not over 250 pounds on the material, it usually requires about three to four men to handle one press. These men load the cheeses and carry them to the press, open and close valves, and unload the press after pressing. This labor, while not skilled labor, brings the cost of operating a single low-pressure machine up to about $1500 to $2000 per annum. Where an industry has a large number of presses in service this can be reduced.

There have been many attempts made to eliminate some of this labor.

Fig. 11 shows one of these devices designed by an English inventor named Mitchell. It was the intention of this inventor to have open boxes for cheeses and mount a railroad over the boxes and move the hopper along on the railroad discharging into the hopper. Each box carried a pipe outlet, and they are connected with a common pipe through which the oil was conducted from the machine. Another inventor some eight years ago conceived the idea of mounting twenty-four hydraulic presses on a turntable and having the turntable rotate intermittently and having its rotary movements arrested twenty-four times in a complete rotation of the turntable, and when it was arrested one of the hydraulic presses would come in line with an automatic cake former, at which time the said presses would be loaded with the cheeses of meal, after which the turntable would again start and bring another press to cake former, and so on.

FIG. 11.

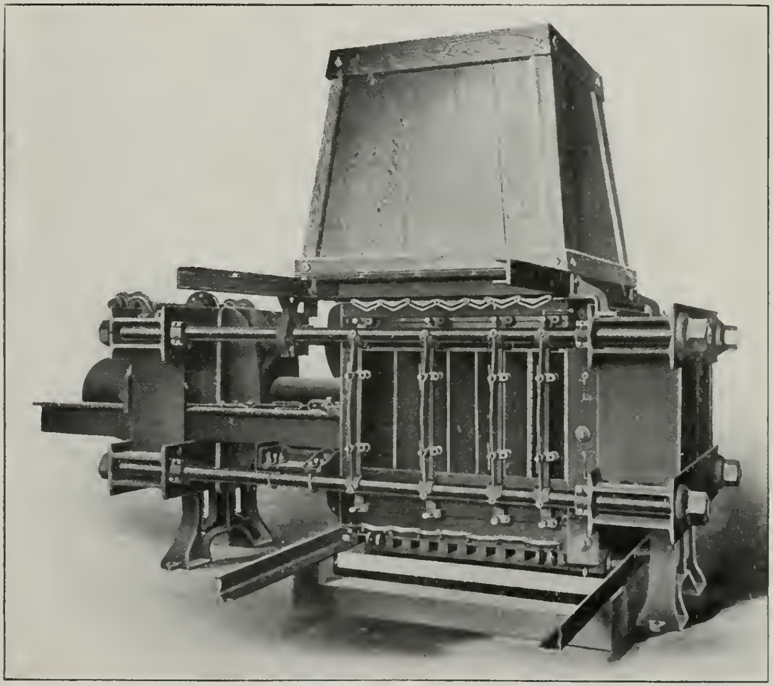


MITCHELL'S OIL PRESS TRANSVERSE AND LONGITUDINAL SECTIONS AND PLAN

In his specification this inventor uses the following language: "In the present invention for several reasons, among which may be named the difficulty of conveying the formed cake from the place where it is made to the various presses of the mill and the difficulty of delivering such cakes to the various chambers of the press, I prefer notwithstanding the great weight of the presses relative to the small weight of the cake to bring the presses one by one to the cake-forming machine and to lower the press platen after lifting to full height, so that chamber after chamber shall come into position to receive the cake from the forming machine without bodily moving the latter, and to discharge the cake by a like press movement, and to this end I mount a series of hydraulic presses, say twenty-four, on a turntable which moves around on a fixed track with a step-by-step motion, one step for each press, and provide said turntable with means for raising and lowering the presses bodily with a step-by-step movement corresponding with the distance between the cake chambers of the press."

Of course this machine was a mechanical monstrosity, and yet I am told one of our large trusts spent the sum of $250,000 building a mill with this machinery. The idea of moving 175 tons of metal to a little cake, weighing at the most not over 60 pounds, is indeed absurd, and yet, so desirous and so anxious are the industries who use these machines to effect economies that one of our great trusts spent the sum of one-quarter million to see if it would work.

FIG. 12.



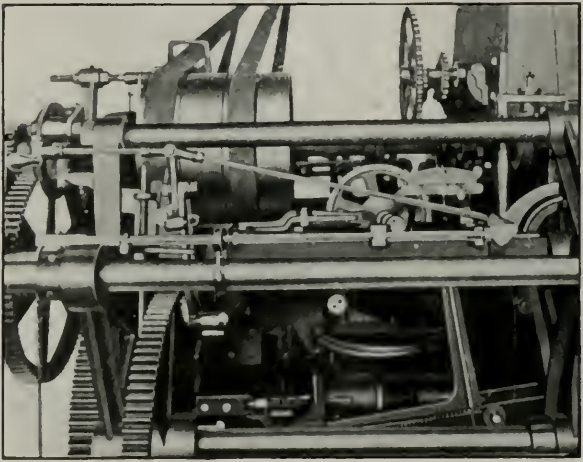
The Herr hydraulic press and compression chamber.

We are living in an age where industrial economies have the call. There never was a time in the march of the world's industrial progress when the conserving of Nature's treasures was more important than it is to-day; never a time in the history of the world's industries when problems of vast economic and industrial import were getting such practical solution as they are to-day; never a time when capital was so alive and so willing to enlist in industries which have for their base valuable liquids now only partly obtained.

I now propose to describe a machine that is destined to effect a revolution in the liquid-extracting industries. It is hydraulic and automatic in its action.

In all industrial operations it is the constant endeavor to replace manual labor by mechanism, and when the latter operates in an automatic and continuous manner, improvement has reached its limit, and it only remains to perfect details and possibly modify them to the end that structural simplicity results.

FIG. 13.



Chamber regulator.

Screw machines and roller machines I scarcely consider seriously. They will gradually all pass off the stage, limited as is their use to-day.

While the hydraulic press gives us the power to do work, this automatic machine that I am now about to describe relieves these machines of all the objection heretofore urged against their universal use as liquid-extracting machines and obviates all their weaknesses.

The present state of development of this machine represents a century of progress. It provides a means, for all industries employing hydraulic presses for liquid extraction, of making their pressing operations entirely automatic.

The machine is self-feeding, self-cleaning, and takes care of the residuum and the extracted liquid. It applies a uniformly distributed pressure and maintains that pressure during a time limit suitable to the requirement of any kind of substance.

The uniformly distributed pressure on all parts of the material leads to high efficiency of operation and a high quality of product. The extraction of moisture is uniform and the residuum is, therefore, dried at small expense.

In addition to the higher efficiency, the predeterminable control of the moisture condition, the superior neatness and saving of labor by its automatic operation increases the production of a plant with less labor than required at present.

Fig. 12 is a general view of the hydraulic press and compression chamber, which lies, horizontally supported, upon suitable foundations.

The compression chamber is rectangular and formed of steel plates supported by braces and attached to the tension rods. The entire chamber is "knock-down" and can in a few moments be dismounted, each plate withdrawn independently or assembled as required.

Within the chamber transverse drain-trays are provided. These are covered with a fine filter fabric to suit the material under treatment. The trays are made of a special wood and conduct the liquid from the material to a collector carried by the bottom of the compression chamber.

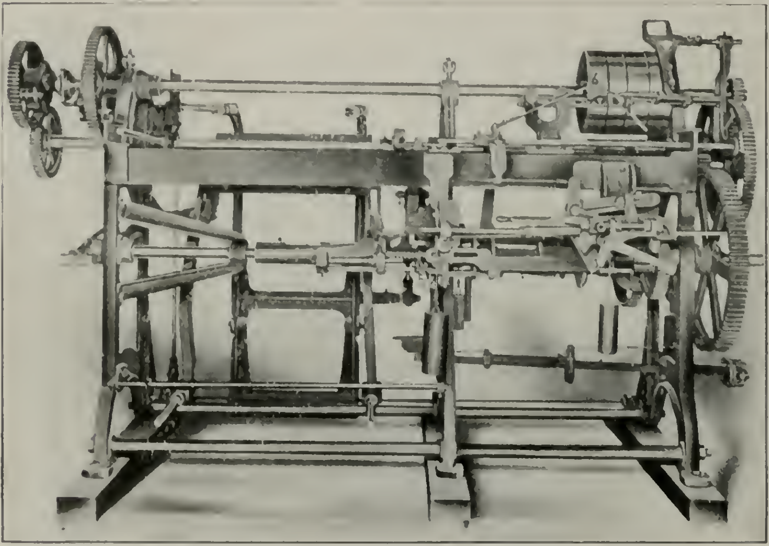
CHAMBER REGULATOR.

Fig. 13 shows the chamber regulator which enables the attendant to adjust the mechanism which controls the rate of feed so that the density will be uniform, the pressure uniform, the liquid extraction and the residuum uniform in the percentage of moisture extracted and retained.

The device not only insures uniformity in density of material in the chamber but also regulates the action of the chamber-cleaning mechanism providing a chamber cleared of all residuum after each pressing. These two important functions, uniformity of density during pressing and complete discharge of all residuum after and between each pressing, yield a practically perfect result.

B in the figure is a clutch controlled automatically or by hand. The automatic control operates by setting an index at a point on the time scale indicating the time during which the chamber is to be kept open for filling. The same regulator controls the time allotted to cleaning, and different materials require different times for this function.

FIG. 14.



The automatic machine.

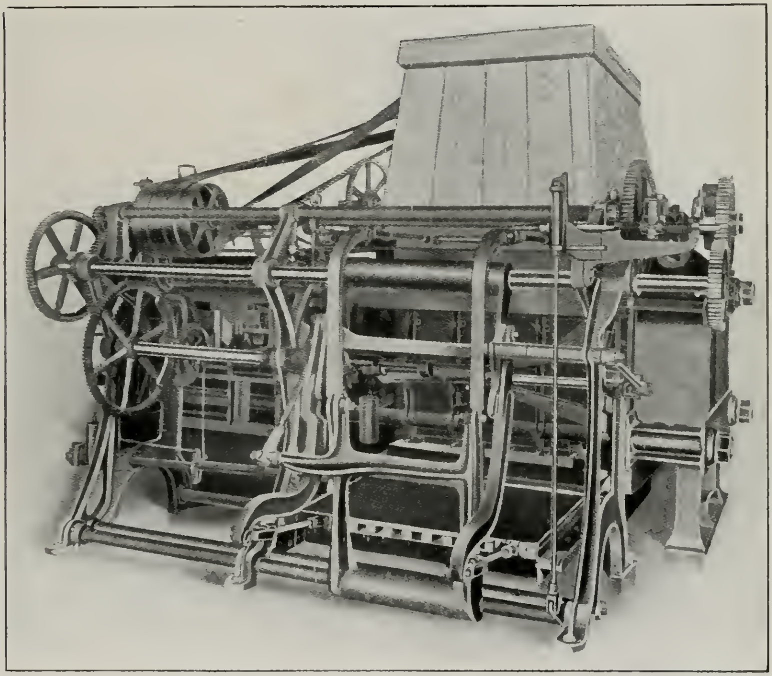
THE AUTOMATIC MACHINE.

The "automatic machine," or the mechanism which operates the opening and closing of the lid of the compression chamber, the bottom of the chamber, the feeders in the hopper, the valves, and, in fact, all the kinetic parts of the mechanical organization is quite simple (Fig. 14).

It is placed alongside of the compression chamber and hopper as shown in Fig. 15 and firmly attached thereto by suitable ties. The moving parts of the compression chamber and hopper are connected to the operating points of the machine and constrained to move in unison with them.

The motion of the hydraulic ram controls the element actuating the bottom of the compression chamber and the motion of the bottom controls the movement of the lid. The exhaust valve from the hydraulic cylinder is operated by the closing of the lid.

Fig. 15.



Automatic machine attached to press.

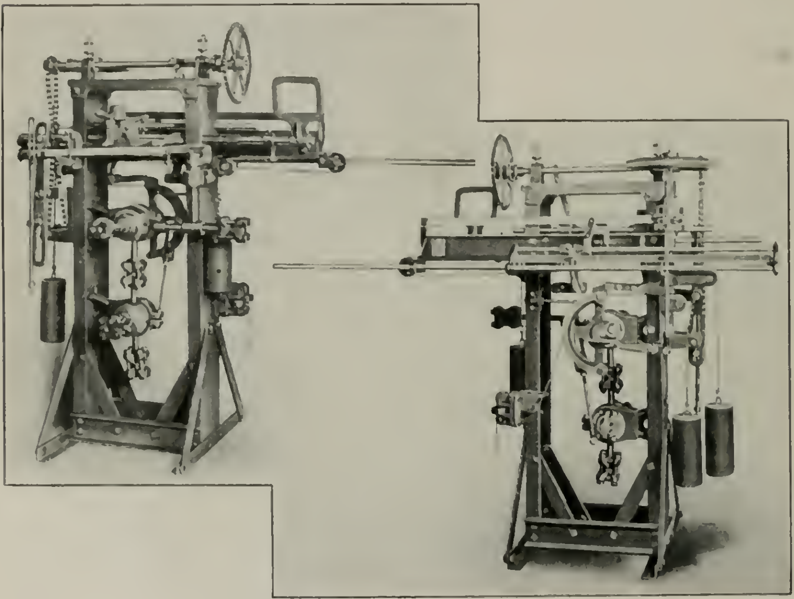
When the lid is closed this valve closes and the pump supplying the ram is started, forcing the platen against the material in the compression chamber.

This pressure continues until the desired maximum pressure is reached as predetermined by the pressure regulator. Thereupon the pump automatically stops and the pressure held at this point for a period which varies with different materials predetermined by the time gauge.

When the time limit has expired the exhaust valve from the hydraulic cylinder is automatically opened and the platen moves back to its initial position.

The drainage partitions within the compression chamber are also automatically separated by the backward movement of the platen and the meal cake is freed from the side thereof. The bottom of the chamber is then opened and the partitions within are cleaned automatically. The bottom is now closed and the chamber is entirely empty. The lid is opened, the chamber again filled, the lid closed, valves operated and pump started—all automatically and with precision.

FIG. 16.



The time recorder and pressure sustainer.

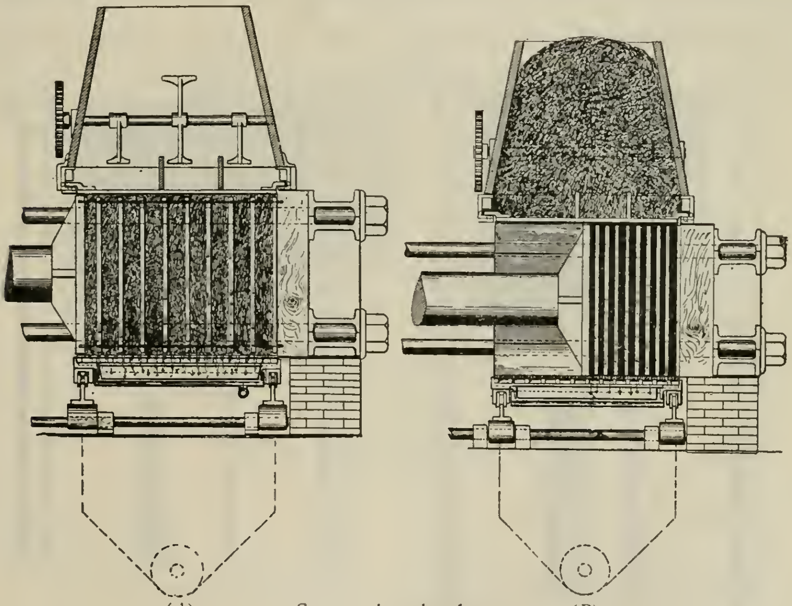
THE TIME RECORDER AND PRESSURE SUSTAINER.

This machine carries the hydraulic high-pressure valves and controls the movement of the ram according to the following requirements:

Different materials require different pressures and a greater or less duration of the maximum pressure. The responsibility for maintaining this maximum pressure for the exact number of minutes required devolves upon the sustainer and so precise is its action that it can be adjusted to the fraction of a minute and the pressure maintained during that period with a variation of less than 1 per cent.

To clearly understand this action, let it be assumed that the required pressure on the ram is to be 2500 pounds per square inch. When the press chamber is full, the pump starts automatically and the pressure rises until the gauge records 2500, at which moment the pump is automatically stopped. Assuming, further, that it is required to maintain this pressure for ten minutes, the index of the time-gauge, Fig. 16, is set at the ten-minute mark.

FIG. 17.



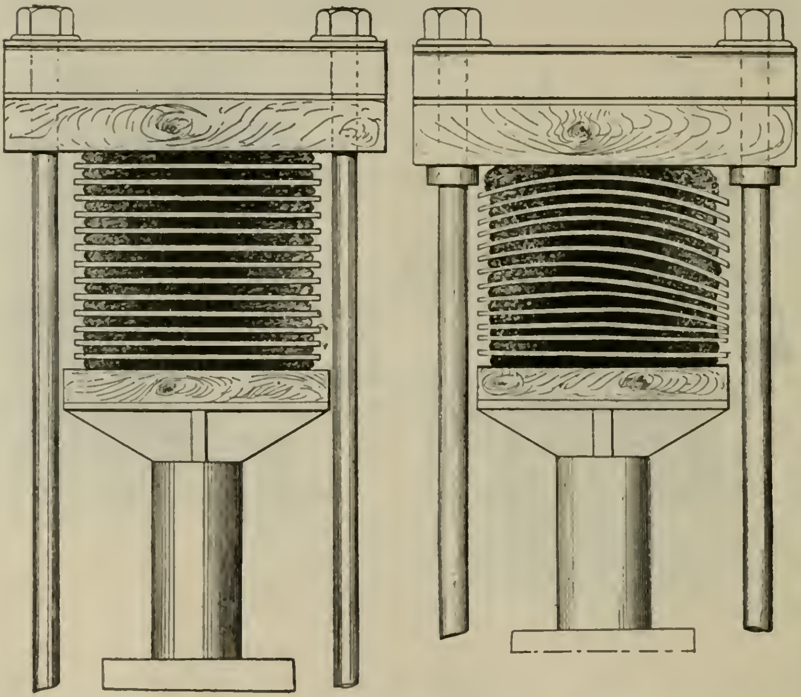
(A) Compression chamber. (B)

This means that the pressure will be maintained on the material for ten minutes, for it requires that time for the index to travel to the zero point of the time-gauge, in which position it trips the exhaust valve, and the pressure is instantly and automatically released.

Fig. 17(A) shows the construction of the chamber. The material is distributed over every part of it and, being contained within fixed walls, cannot diffuse itself. What little creeping occurs is an automatic adjustment to a normal action in obedience to natural laws.

Fig. B shows the ram after the material has been subjected to the maximum pressure. Fig. A shows the chamber loaded before pressure, the even density in B, how the parallelism of the drain-racks is maintained. The distortion of these racks under the former practice is illustrated in Fig. 18. The strain cloths have longer life by the elimination of the tearing, twisting and abrasive action upon them. They are subjected to compression stresses only, no tension as at present—a feature of great economy. Careful tests have demonstrated that, in point of efficiency, no other machine can approach the automatically controlled hydraulic press fitted with a chamber of this design. The zone of pressure is uniform and the extraction is uniform over the entire area of the chamber and, indeed, on the entire mass of material.

FIG. 18.

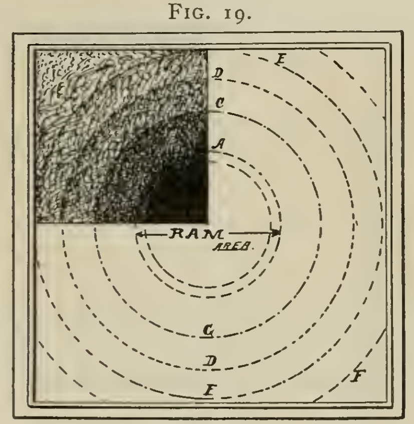


Distortion of racks.

Fig. 19 indicates the lack of uniform density in the usual form of low-pressure hydraulic machine. The "ram area" has an abnormally great pressure between the circles A and C which is too high and bad work is the result. Within the annular space D and C the pressure is about correct; no waste of gluten or solid nutritious matter occurs and the proper percentage of moisture is obtained. Beyond the circle D too much moisture is left in the material that should be extracted. Beyond the circle E the material creeps and tears the cloths. All these faults exist in the common practice and all are avoided by the automatic press.

With this press the daily capacity of everything is increased from 20 per cent. to 40 per cent., with less fuel consumption and the elimination of all labor except engineering attention and administration.

FIG. 19.



Variable density.

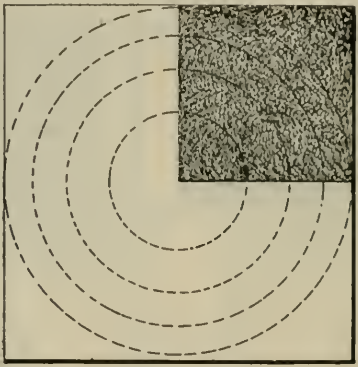
All the power, in addition to the labor, now used in pumping against safety valves at high pressure is saved. This saving with a 12-inch ram is at least $300 per annum, with a 16-inch ram about $500, and with a 20-inch ram about $750 for each machine in daily use.

The economy in labor effected, as compared with the ordinary press, is three men for each low-pressure machine, or a minimum of $1500 per annum. Of course when a large series of machines is in use this can be reduced. With high-pressure machines it would be less.

The economy is measured by the difference between evaporating the 60 per cent. moisture in material supplied by a screw or roller machine, which is about the best performance of either, and the 30 per cent. moisture contained in material from the automatic press. This is a difference between 3000 at 60 per cent. moisture and 857 at 30 per cent. moisture (see table), or 2143 pounds of water which must be evaporated by the dryer.

It will therefore require almost three times the dryer capacity, for instance, to dry brewers' grains passing through a roller press, that is needed for the same material from the automatic press. In the former case the most valuable part of the grain is lost and in the latter this valuable part is saved. What is true of brewers' grain is equally true of all substances. It is specifically mentioned as representative only.

FIG. 20.



Uniform density.

The important features peculiar to the improved machine may be thus briefly summarized:

It is automatic in every particular; it produces a maximum pressure with accurate uniformity on independent press loads and on every part of the same press load; it will sustain the maximum pressure as desired without power, all power being cut off at the maximum pressure. The period for maintaining maximum pressure can be varied to suit any condition or material; it increases the capacity of the ordinary press without increase of power or labor required; the automatic control and operation of the machine makes the process comparatively independent of labor disturbances and thus relieves users from many annoyances and anxieties attending ordinary press-room conditions.

MECHANICAL DRYERS.

Dryers are employed to reduce the moisture from the material after it leaves the press to a condition of commercial dryness, or 8 per cent. Few,.if any of the present presses extract moisture to 60 per cent. and it is the function of the dryer to reduce this moisture to 8 per cent., which means that the dryer must evaporate 2826 pounds of water for every ton it dries, and where a plant is producing 50 tons per day, 143,300 pounds of water must be evaporated.

Whenever the nature of the material will allow of the direct use of gases or combustion, the economy over the use of steam is very great, and in a well-designed and well-constructed apparatus the best authorities estimate that the expense will be from 40 per cent. to 60 per cent. less.

In steam there are several losses inseparable from its use:

1. Imperfect combustion by fuel under boiler.
2. Loss of heat in chimney.
3. Loss of heat by radiation in conductors leading from the boiler to dryer.

Even the use of exhaust steam involves a condition of such low temperature in the dryer that the function of drying is accomplished with reduced intensity, and as a result numerous dryers become necessary, with the attending extra cost of maintenance.

Packers' plants, garbage plants, fish-oil mills, chemical establishments, distillers' slop plants, beet mills, brewers' grain mills, sizing plants, all use low-pressure machines and dryers.

The low-pressure machines, if hydraulic, give a pressure of from 300 pounds on the ram area to 10 pounds on the perimeter of the cheese and an average extraction of approximately 46 per cent. with conditions favorable, and when the hydraulic indicator shows 3000 pounds' pressure in the cylinder the ratio of distribution of the pressure on the mass is about as 1 to 4, with one part of the mass being under the pressure indicated by 4, and 4 parts of the mass being under the pressure indicated by 1 and so on conversely at intervening ratios. Therefore, a large portion of the mass is not getting sufficient pressure and a small portion too much.

With the machine I have described we bring the pressure uniformly on the mass, after predetermining the proper pressure to do the necessary work, and this can be varied to suit any condition, and in low-pressure work in the industries above described we reduce the moisture to 30 per cent. and lower. That means that for every ton of dried material we press out with this machine about 900 pounds of moisture more than is possible by present hydraulic open cheese presses. That means that we save the dryer in doing this work the necessity of evaporating that 900 pounds of water, less 8 per cent.

Now let us see what screw machines and roller machines will do.

These machines in beet-sugar pulp do not reduce the moisture below about 80 per cent. Beet sugar is peculiar in that the water is in the beet after the sugar is out. It is different from a material in which the water is around and about the material. In the latter gravity of mass will cause the moisture to be reduced, as in brewers' grain, but not so in beet-sugar pulp or any similar substances. It must be pressed. Each individual cossette must be pressed.

The Bergreen pattern of screw press is used here and abroad largely for this work, but they do not press below 80 per cent. moist. So for each ton of dried beet pulp there still remains 8000 pounds of water which must be evaporated by the dryers.

The hydraulic press I have described will bring this moisture down to 30 per cent. and could carry it lower. This means an actual water extraction of 7000 pounds or more per ton.

In an industry that is operating 70 factories with about 1000 tons per day per factory such economy means something. New wealth is created by such methods; it is an industrial quickening, an industrial awakening, and the dawn of a new and a brighter era.

What is true of beet sugar is true of numerous other industries.

There are 30,000,000 pounds of old rubber shoes each year that go through some sort of press to be reformed and revitalized into commercial values. Here the same economies can be effected.

There are from 2000 to 3000 breweries in this country having a valuable product in their grains. The economies effected by the machine I have described will create a large industry in expressing the moisture from the millions of bushels of barley, some of which is now treated by expensive and inefficient liquid extractors and ineffectual dryers.

The peat bogs of the country, comprising vast areas, need but the quickening touch of an efficient and economical liquid extractor to be a source of vast wealth and a yet comparatively unborn, or at least undeveloped industry, will bloom and spring forth as one of our conspicuous staples.

The waste refuse of our civilization and particularly of our cities is laden with valuable oils and other useful products.

These by-products cannot be economically obtained without efficient pressure to separate the oils and liquids from the solid residuum associated therewith. To incinerate this material is an industrial crime, and gradually with such machinery as thus described obtainable, these products will be reclaimed, a new industry created, and the health and happiness of our people be the greater therefor.

The sea with its teeming millions of fish has ever been a source of wealth among the nations, but the oils in the fish that cannot be marketed as eatable will be marketed from many industrial establishments not yet born, but which will spring into being because profit can be made from capital engaged in the fish-oil and tankage industry with an automatic and efficient plant such as this mechanism will give.

There are about 2,500,000 tons of sugar made annually. The average of sugar contained in high-grade cane is about 21 per cent., in high-grade beet sugar 18 per cent. to 20 per cent. The value of the annual product should be about $250,000,000 if it could all be extracted, but one-half is not obtained. Possibly a scientific press room may figure in important economies in the sugar business.

With all the progress made in the years that are past, with all the accomplishment in the sciences, in the arts and in material well being, the student and thoughtful man has before him far greater possibilities than any that are history. With the keen intelligence, the irresistible ambition, the driving, pushing characteristics of well-directed energy and with the patience to go slow that we may move fast, who can measure, as a people, our achievement, and who can estimate the part that automatic, labor-saving, production-increasing machinery will play in the financial successes, the industrial battles and victories of the future!

PRESSES FOR THE EXTRACTION OF LIQUIDS.

[Report of the Franklin Institute, through its Committee on Science and the Arts, on the improvements in presses for the extraction of liquids made by Homer A. Herr. *Subcommittee:* James Christie, chairman; Tinius Olsen, Wm. H. Thorne, Thomas P. Conard, Hugo Bilgram. No. 2422.]

The inventions of Homer A. Herr relate to presses for the extraction of liquids from various substances, and apply most especially to hydraulic presses. They comprise mechanism for automatically feeding the press, for cleaning it of the solid remains of the substance pressed, for regulating the pressure required and varying the maximum pressure desired, and varying and regulating the time during which the pressure exists, and for sustaining this maximum pressure for any desired period.

These several operations are all accomplished continuously and automatically and without any direct attention from the operator, after the mechanism is once adjusted for its purpose, thus enabling one skilled operator to attend to several presses, and dispensing with considerable manual labor, especially in the handling of material, which is frequently unattractive in character, and apparently also in imparting to the press greater certainty and precision of operation than can be realized when these operations are directed by hand.

This mechanism is fully described in U. S. letters patent Nos. 801,872 and 819,996 dated October 17, 1905, and May 8, 1906, also in two pamphlets issued by the Herr Automatic Press Company. This mechanism is so intricate that it cannot be satisfactorily described in detail verbally, therefore reference is made to the aforesaid documents for description of details.

The mechanism can be divided into three separate elements as follows:

1. The press proper, which may be of any of the usual forms of hydraulic extraction presses, but necessarily horizontal in position.

2. The mechanism for regulating and controlling the feeding, cleaning, and discharging of the material to be pressed.

3. The mechanism for controlling the intensity of the pressure, and the time it has to be sustained.

In addition to the foregoing Mr. Herr has embodied a method of encasing or holding the material to be pressed, whereby this material is subjected to a more uniform pressure throughout its mass, than is usual in the ordinary presses, a matter of considerable importance in some of the industries. This is accomplished by enclosing the material within metallic frames which prevents the lateral spread of the material under pressure, and tends to distribute the pressure more uniformly than when the material is enveloped in the usual fabrics, and without any rigid support at the outer edges of the masses, but is free to flow in a lateral direction.

There are found in the annals of the Patent Office a few related inventions which are intended to accomplish partially some of the purposes sought by Mr. Herr, but no records can be found of any attempt so complete and thorough in their automatic actions as the devices heretofore described.

The extraction of liquids from materials is a very extensive industry, and embraces a great variety of products. Any mechanism that will expedite or economize in time or cost, will prove a direct advantage to the industrial arts and to the community. Mr. Herr's work is the result of several years of effort.

The apparatus for feeding, cleaning, and discharging the press, as illustrated by several views in Book A, having been found somewhat complex and lacking in general rigidity, Mr. Herr has constructed a simpler machine operated electrically, which appears to be an improvement on his first design.

The Subcommittee has seen these several mechanisms complete and in motion, and although Mr. Herr has not yet put these into practical operation, he has accomplished enough to make it appear probable that he has made a distinct advance in the economies of an important industry. For the skill and intelligence exhibited in developing this ingenious mechanism, the Franklin Institute suggests the recommendation of the *John Scott Legacy Medal* and *Premium* to Homer A. Herr for his improvement in presses for the extraction of liquids.

Attest: ALFRED RIGLING,
Acting Secretary.

Philadelphia, May 6, 1908.

FRANKLIN INSTITUTE

NOTE ON THE ACTION OF ALUM ON SCHUYLKILL WATER.

BY
HENRY LEFFMANN.
Member of the Institute

The experiments described herewith were undertaken to get some information as to the operation of a mechanical filter system, installed in a large general hospital in this city. An older portion of the building had been supplied under this system for several years, and the hot water pipes had been seriously clogged and pitted. It was feared that the new installation would also be injured and it was, therefore, desired to determine the cause of the pitting and remedy it if possible. The present installation consists of two mechanical filters, installed by different companies, but operating on the same fundamental principle, although differing in some details. Both use an aluminum salt for coagulation and then force the water through a filter-bed under pressure. In addition to the injury to the pipes, it has been noted of late that the water is not efficiently filtered, the effluent being often distinctly turbid.

The installing companies have been consulted and their engineers have made reports. One expert suggests lime water in place of the aluminum solution, a method that promises well and has been a good deal used where corrosion occurs. My own relation to the case arose from the fact that I hold an honorary position on the hospital staff, and the medical director wanted my assistance. I thought it interesting to determine whether the effluent contained excess of alum, because, as an expert of a filter company once said at a meeting of the American Water-works Association, the usual plan when the effluent is unsatisfactory is "to slap in the alum."

Excess of aluminum salt may be detected by Mrs. Richards' test, but the reagent, fresh logwood chips, is not easily obtained.

As the coagulant is usually aluminum sulfate either as such or in the form of alum, it becomes possible to detect its excess by the influence on the alkalinity of the water. After trying several indicators I found most satisfaction with sodium alizarinmonosulfonate, an indicator now much used in gastric-juice analysis. This dissolves freely in water, the strong solution being dirty brown, but a few drops in 250 c.c. of Schuylkill water produce a purplish-red liquid which becomes yellow on acidifying. If aluminum sulfate or aluminum chloride is present, the solution is brownish yellow and is not changed by addition of small amounts of mineral acid.

It appeared, therefore, possible to determine easily if the automatic supply of coagulant was working properly, especially if an excess of the aluminum salt was being used. Some preliminary experiments were made by adding known amounts of alum to Schuylkill water. Crystallized ammonium alum was used, on account of its uniform quality and general purity. Amounts of it, ranging from a ratio of 1 grain per U. S. gallon to 10 grains, were added to the water, allowed to stand 24 hours, filtered through paper, and titrated. The usual method was to to take portions of 500 c.c., add the required amount of alum dissolved in a little distilled water, and after 24 hours, filter, collect 250 c.c. of filtrate, and titrate this. It was found that the untreated water required a little over 2 c.c. of decinormal sulfuric acid. This was a supply at the Woman's Medical College. Experiments made in the centre of the city show practically the same alkalinity. I found that as much as 9 grains of crystallized ammonium alum can be added to Schuylkill water without overcoming the alkalinity or leaving unchanged alum. I was somewhat astonished at these results, but on calculation of the respective molecular weights the fact is explained. One molecule of alum will react with 3 molecules of any of the normal carbonates, hence 9 grains of crystallized ammonium alum will decompose the following amounts approximately:

Calcium carbonate	3	grains
Magnesium carbonate	2.5	grains
Potassium carbonate	4	grains
Sodium carbonate	3	grains

At my suggestion, a series of daily tests was made on the applied and effluent water at the hospital. As the data were merely relative, arrangements were made to have a uniform volume of water tested with acid of uniform strength. The figures have, therefore, no absolute value, but are very instructive relative data. Dr. Funke, the chemist in charge of the hospital laboratory, made a considerable number of tests, of which a few are here appended. The figures are the c.c. of acid required to produce an acid reaction to the alizarin reagent.

Date	Raw water	Effluent
11	2.85	0.75
12	2.85	2.6
13	2.9	1.6
15	2.85	0.5
16	2.7	1.75
17	3.0	1.1
18	2.8	1.5
23	3	1.9
25	3.5	2.55

The figures show the comparatively slight variation in the alkalinity of the water, and the great variability of the alum feed, indicating that the operation of the filter requires much more careful supervision than it is receiving.

RUBBER-TANNED LEATHER.

A BRITISH publication states that a new syndicate has established a factory in London and is placing upon the market a new form of leather, for which it is claimed there is a big future, and which it thus describes:

The leather is submitted to a tanning process of the chrome variety, which preserves it; rubber solution is then worked into the interstices, rendering the hide thoroughly waterproof. The elasticity of the rubber permits of perfect flexibility and extraordinary toughness of some of the skins, especially of rabbit, goat, and sheep skins. It is impossible to forecast the many uses for which this process may be available. Tests have been made for motor tires, soles for boots and shoes, pump washers, machine belting, miners' boots, etc., and it is probable that the multitude of articles that can be made of rubberized leather will, in time, create a further demand for rubber. This new material, it is thought, may also prove useful for motor and cycle tires, as it is almost impossible to puncture it, while it is said to be much more resilient and waterproof than ordinary leather.

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FRANKLIN INSTITUTE

(*Proceedings of the stated meeting held Wednesday, March 17, 1909.*)

HALL OF THE FRANKLIN INSTITUTE,

PHILADELPHIA, March 17, 1909.

President WALTON CLARK in the Chair.

Present, seventy members and visitors.

Additions to membership since last report, four.

The Chairman introduced Mr. J. Kent Smith, Chief Metallurgist of the American Vanadium Company, Pittsburg, Pa., who spoke on the subject of vanadium and its applications to the heavy arts. The lecturer reviewed the history of the metal and described its modes of occurrence and its present sources of supply. Steel as normally constituted was considered and the effects produced upon it by vanadium. Results of tests of vanadium steel and its behavior in actual service were shown. The subject was illustrated by lantern slides and numerous specimens. Mr. Smith then called upon Mr. E. Warren Wilson, President of the Union Saw Company, Williamsport, Pa., who gave an interesting exhibition of saws made of vanadium steel.

The next speaker of the evening, Mr. Albert Stetson, of New York, described the Shore scleroscope, a direct reading instrument for testing the hardness of metals and other solid bodies. The apparatus was exhibited by Mr. Albert F. Shore, the inventor.

At the close of the meeting a vote of thanks was tendered the speakers. The two subjects presented were referred to the Committee on Science and the Arts for investigation and report, and the lecture on vanadium was referred for publication. Adjourned.

JAMES CHRISTIE,
Secretary.

PRESS OF
J. B. LIPPINCOTT COMPANY
PHILADELPHIA

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DEVOTED TO SCIENCE AND THE MECHANIC ARTS

VOL. CLXVII MAY, 1909 No. 5

FRANKLIN INSTITUTE

IDENTIFICATION OF HUMAN BEINGS BY THE SYSTEM OF ALPHONSE BERTILLON.*

(*Concluded.*)

BY

PERSIFOR FRAZER.

DESCRIPTION OF REGISTER FILES.

It is necessary here with this rough sketch of the stacks in view to claim your close attention to a description of the method by which M. Bertillon classifies the records. This device of his is the real heart of the whole system. Anybody can construct a system of measurements which will differentiate living beings from each other, but to construct a means of so classifying them that one can go almost immediately to the case in which the previous record of an unrecognized but suspected recediviste or old offender will be found, requires the highest order of invention.

The function of the anthropometric service is to obtain from the prisoners brought to it a certain number of osseous measure-

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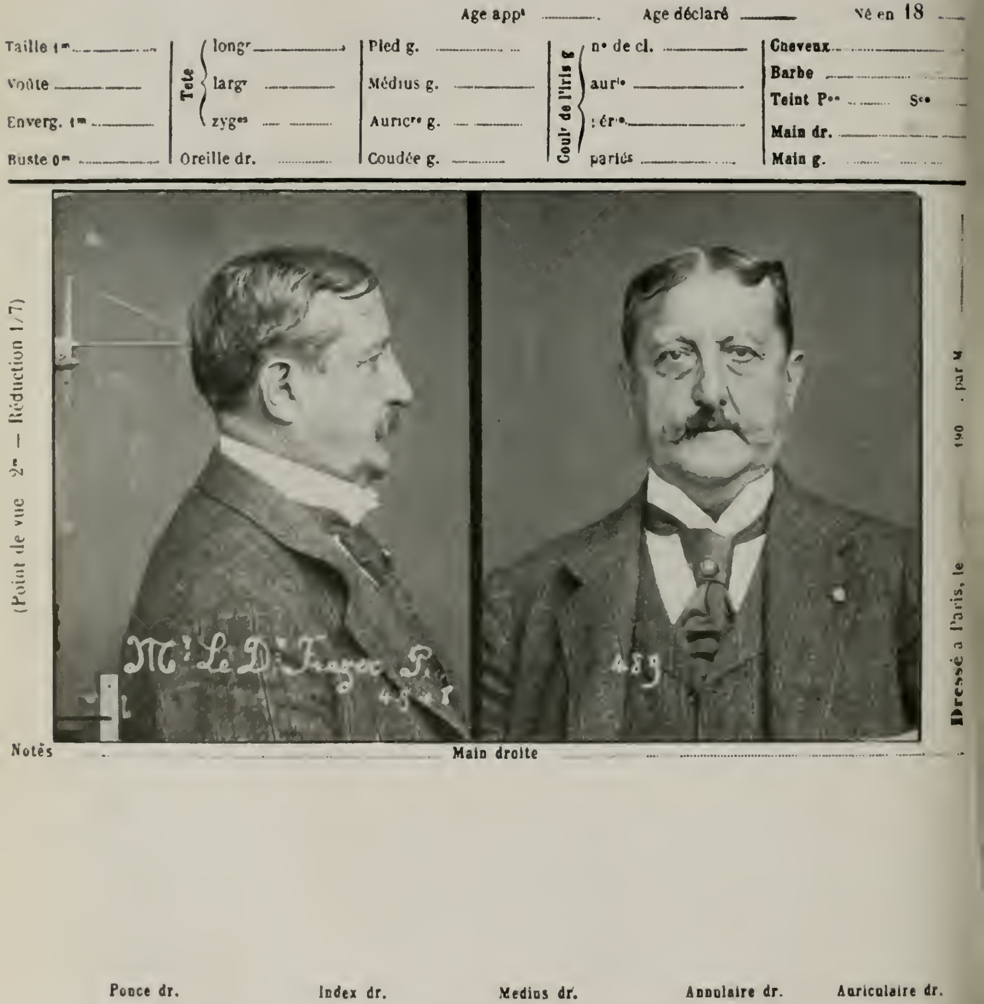
* A lecture delivered in the Franklin Institute Popular Science series, Feb. 15, 1909.

[NOTE.—The Franklin Institute is not responsible for the statements and opinions advanced by contributors to the Journal.]

ments, using the figures thus obtained as a basis to classify the photographs of individuals, after the manner of a classification of flora, etc., to enable one ultimately to find, in a collection destined to contain several hundred thousand specimens, the portrait of an old offender who has concealed his identity under a false name and a disguise.

FIG. 11.



Age app^t .... Age déclaré .... Né en 18 ....

Taille 1^m	Tête long^r	Pied g.	Coul^r de l'iris g n° de cl.	Cheveux ....
Voûte	Tête larg^r	Médius g.	aur^{le}	Barbe ....
Enverg. 1^m	Tête zyg^{ne}	Auric^{re} g.	pér^{ie}	Teint P^{on} .... S^{ce} ....
Buste 0^m	Oreille dr.	Coudée g.	pariés	Main dr. ....
				Main g. ....

(Point de vue 2^m — Réduction 1/7)

Dressé à Paris, le .... 190 . par M ....

M^r Le D^r Frazer P.
489
489

Notés .... Main droite ....

Pouce dr. Index dr. Medius dr. Annulaire dr. Auriculaire dr.

Suppose the collection to contain sixty thousand records. The first division is based on the longer diameter of the skull. In all cases the order is from small to great. Then the division containing records of these would be

short *heads*	↓	20,000
medium *heads*		20,000
long *heads*		20,000

Each of these three divisions of 20,000 is further divided into

narrow *heads*		6000 +
medium *heads*	→	6000 +
broad *heads*		6000 +

Each of these three divisions of 6000 is further subdivided into

long *middle fingers*	↑	2000
medium *middle fingers*		2000
short *middle fingers*		2000

Each of these last divisions of 2000 is further subdivided into

short *left foot*		600 +
medium *left foot*	→	600 +
long *left foot*		600 +

These again into

long *left forearm*	↑	200
medium *left forearm*		200
short *left forearm*		200

These further into

small *little finger*		60 +
medium *little finger*	→	60 +
long *little finger*		60 +

These into

long *right ear*	↑	20
medium *right ear*		20
short *right ear*		20

These into heights

short		6 +
medium	→	6 +
tall		6 +

and these six remaining from the 60,000 original cases are further differentiated by the color of the eyes. So that but a few minutes would elapse from the first glance into the head-length box till the agent had traced the individual whose record-slip was given to him down to the ear-division, and selected by the eye-color determination which of the six slips if any correspond to that in his hand.

With six anthropometric characters (those of sex, height, age, eye-color have always been used) sixty thousand photograph-records of the préfecture of police are reduced to divisions of a dozen photographs which are easily scrutinized.

To maintain a classification of this character at a uniform number of cases it is necessary, in the first place, to pay attention to the presumed age to within twenty years, so that the persons born 1830–49, 1850–69, 1870–89, will fall together. In searching the files as described when the measure indicates a place near the dividing line, say between small and medium, one must search both divisions.

> A table is given showing the numerical indication of the limits of each tripartite division up to and including the elimination by the forearm; the grouping being taken exactly from the order and disposition observed in the separate cupboards. Each of these sections in cupboard I, II, and III is employed by a different category of head-length: 1, small, 2, medium, 3, large. The vertical pieces which divide them into three parts separate the three divisions of head-breadth. Each of these parts is again redivided into three, corresponding to the three divisions of the middle finger.
>
> Each of these small sections increasing from below upwards is again subdivided by vertical walls increasing from left to right for the foot; and each of these latter is again divided from below upwards for the forearm.

Each of the smallest divisions is contained in a small box called a cabriolet, like the similar boxes in desk files, which bears on its front end the following inscriptions:

I.—Head length IV.—Foot
II.—Head breadth III.—Middle finger
V.—Forearm.

The maximum and minimum values found by experience to apply to each of these five divisions in this section of the anthropometric files is affixed to it.

The photographic print added to the numerical record for each person is composed of two pictures juxtaposed; the one, a profile of the right side of the face, and the other a full view, both exactly one-seventh natural size.

On the back of the photographic card are data giving with the precision of anatomic description all the cicatrices, simple marks, or cuts, etc., which each individual possesses.

The measures, the photographs, and this description of special marks permit the determination of an individual after many years of interval to a very high degree of certainty.

To make it still clearer: you observe the sets of three stacks joined together but separated by vertical partitions. The picture only represents twelve horizontal shelves and three of the nine vertical subdivisions.

Imagine twenty-seven shelves divided by horizontal lines into three sets of nine shelves each; and three groups of stacks divided by vertical lines into three sets of triple stacks like the one you see in the picture. The upper nine shelves are devoted to small head lengths, the middle nine shelves contain medium head lengths; and the lower nine shelves large head lengths from left to right throughout the entire series of nine stacks.

The three highest vertical divisions on the left contain small head breadths; the middle three vertical divisions medium head breadths; and the three stacks on the right hand large head breadths.

These two capital divisions (in both senses) I and II head lengths and breadths sweep from the left-hand upper corner downward in increasing head lengths. Head breadths are also found on the uppermost shelf to the left and grow in size in lines to the right upwards from bottom to top and across from left to right of the entire system of twenty-seven horizontal and nine vertical divisions. The smallest head length will be found recorded on the upper row to the extreme left. It is 18.3 cm. on the upper nine shelves; 18.4 on the middle nine shelves, and 19 on the lower nine shelves.

These figures are used by M. Bertillon to cover freaks: −18.3 means from the smallest possible head length observed (theoretically just above 0) to 18.3 cm.; and 19−, from 19 cm. to the largest possible measure.

The smallest head breadth will also be found in the upper left-hand cabriolet. It is −15.2 throughout the left-hand three vertical divisions; 15.3−15.7 through the middle three vertical divisions; and 15.8− throughout the three right-hand vertical divisions.

Datum III or the length of the left middle finger divides horizontally each of the first-mentioned grand divisions into three parts containing three shelves each, but in each of these the increase of number is from below upward and not, as in the head length, from above downward.

Datum IV or the length of the left foot divides each of these last-mentioned groups of three shelves into three of a single shelf each, in this case also increasing numerically upward. Finally Datum V, the length of the left forearm, is classified in three cabriolets on each shelf, the numbers increasing from left to right.

Suppose a prisoner presents the slip containing the records of measurements just made by the measuring officers to the officer who presides over the records, and that this slip contains the data I—18.6, II—15.7, III—11.3, IV—25.7, V—45. The case is purposely chosen because it lies in the least definite part of all the data—the medium. Nevertheless the agent would promptly go to the middle nine shelves representing the medium head length, and passing to the right would halt at the section containing the middle vertical group of three stacks and the middle

> horizontal group of nine shelves. He would do this because the head breadth of the left-hand group of three stacks is shorter than the datum and the right-hand group of three is longer.
>
> Somewhere there among these twenty-seven shelves will be found the measure of the prisoner if one there is.
>
> He would eliminate the top and bottom groups of three shelves each because on these the datum III or little middle finger length would be too small or too large. By datum IV the left foot length he would eliminate the upper and lower shelves of this middle group of three shelves and thus there would remain but three vertical divisions of the middle shelf of the middle section. Here datum V, the length of the forearm 45, would at once decide him to look into the middle cabriolet of the middle shelf and there he would find—if it had been taken—the measurements of his man together with his real name and civil station.

In anthropometric classification, the designation of the classes small, medium, large, it follows that the medium must be the narrowest division.

> Suppose we begin a search by the element of height, the medium division will include only those with a height of 1.62 M. (5.41 ft.) to 1.67 M. (5.47 ft.), whereas the larger will include those from 1.68 M. (5.51 ft.) to the giant of 2 meters (6.56 ft.), and the small will include those with a height of 1.62 M. to the liliputian of 1. M. (3.3 ft.) and a few centimetres.
>
> The division of the binomial curve shows that to realize this condition in a general way the limits of the category of medium must not vary above nor below the arithmetical mean more than an amount equal to 0.63 of the probable error or half the variation of half of the cases. It follows as a matter of course that the arithmetical mean of each measurement varies according to the division small, medium, or large, of the preceding measurement. It is thus that in parting from the elimination by the middle finger to that by the foot, the arithmetical mean of the foot of those endowed with a small middle finger will be notably different from the similar value observed in those with a large middle finger.

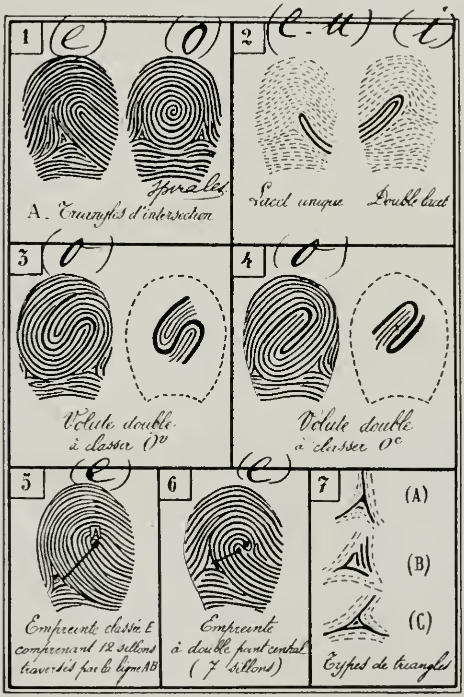
M. Bertillon has strictly forbidden his employés from informing the interested individual when he is identified. A few notes are taken and he is dismissed to the depot, but the facts are put into the possession of the magistrate who is to try him, and this will explain the frequent dramatic sensations produced when, after the prisoner arraigned before the magistrate, has answered that his name is Jean Bourdet, a carpenter, living in the Rue Mesnil, unmarried, and twenty-four years old, the genial justice replies: your name is Eugene Tridot; you were arrested for highway robbery and attempted assassination on June 17, 1902; you were also imprisoned for beating your wife almost to death; you were born in Lyons, are thirty-seven years old and have served three terms of imprisonment.

In more than 2300 recognitions thus transmitted to the trial magistrates not a single one has caused any confusion or embarrassment which a mistake would have been sure to occasion.

FINGER PRINTS.

For a long time after Francis Galton had made known the usefulness of finger prints for distinguishing individuals M. Bertillon took no notice of the method. Singularly enough Galton began his study in 1888 indirectly through the instigation of the Bertillon system. He says (in the introduction of the edition of 1892), "My attention was first drawn to the ridges in 1888 when preparing a lecture on personal identification for the Royal Institution, which had for its principal object an account of the anthropometric method of Bertillon then newly introduced into the prison administration of France." Further on (p. 15) he makes this statement: "For aid in searching the

FIG. 12.


1
(e)
(o)
Spirales
A. Triangles d'intersection
2
(e-u)
(i)
Lacet unique
Double lacet
3
(o)
Volute double à classer O^v
4
(o)
Volute double à classer O^c
5
(e)
A
B
Empreinte classée E comprenant 12 sillons traversés par la ligne AB
6
(e)
Empreinte à double point central (7 sillons)
7
(A)
(B)
(C)
Types de triangles

records of a criminal bureau its (the method of finger prints) proper rank is probably a secondary one; the primary being some form of the already established Bertillon anthropometric method. Whatever power the latter gives of searching registers that power would be multiplied many hundred fold by the inclusion of finger prints, because their peculiarities are entirely unconnected with personal characteristics." * * *

> In this same book is an interesting examination of the merits of Bertillon's system (chap. X).
>
> Galton found after classifying 500 Bertillonized cases by taking the measures of head length, head breadth, span, body height and middle finger, the results were not entirely satisfactory. Eighty-three possible cases out of 243 (3^5) or ⅓ of the total number possible were not represented at all by actual observation. Twenty-four sets fell under one head in one instance; in others 14, 11, and 10 did so. The case was different where instead of five, seven measures were taken. He believes that this number of datum points will enable one easily to separate and individualize 500 cases, and perhaps many more.
>
> Galton's method of classifying finger prints is thus given (p. 71) in his book.
>
> "It may be convenient when marking finger prints with letters for reference to use those that look alike both in a direct and in a reversed aspect, as they may be required to be read either way. The print is a reversed picture of a similar pattern on the digit that made it." * * *
>
> There are twelve capital letters of the English alphabet which in block type are unaffected by being reversed; namely, A, H, I, M, O, T, U, V, W, X, Z. Some symbols, such as *, +, —, =, do the same; and H, O, I, X have the further peculiarity of appearing unaltered when upside down.
>
> He divides the patterns of finger prints into three categories: arches, loops, and whorls.

When M. Bertillon comparatively recently finally decided to avail himself of these wonderful phenomena to strengthen his system, he made his own classification, rejecting Galton's. To this end the four vowels "e," "i," "o," "u" are used to indicate the four types into which the patterns of the finger prints are divided.

The type "e" was that pattern in which the lines forming the loops resting on the usual triangle of intersection near the middle of the impression extend from left to right downward; their closed ends being above and to the left, and the free ends descending to the right. To justify the designation there must be at least two such loops.

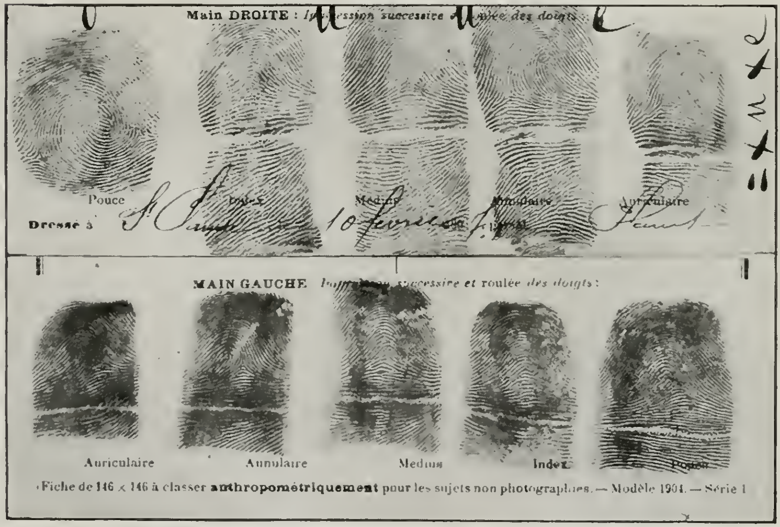
The type "i" is that pattern where at least two ridges indicated by black lines in the impression have their closed ends to the right, above the triangular places of intersection, forming an oval, or spiral, the latter either concentric or as volute.

The type "o" is that where the digital lines appear to the number of at least 4 between the little triangular patterns marking the central point of each finger tip; and their form is oval, spiral, or volute.

The type "u" is that pattern in which the lines are superposed in the form of an arch, flat near the bottom and higher on top.

The prints are taken in the following manner: A plate of zinc or glass is covered uniformly with printer's ink rolled out to a thin film, the person whose finger prints are to be taken is placed to the left of the operator who takes the subject's right hand and keeps, successively, the thumb and the other digits extended by taking the extremity of each in turn between the thumb and index of his own right hand and holding the base of the finger with his left hand. The front of the third joint of each finger in turn is then rolled lightly on the plate covered with ink, and immediately afterwards the same action is repeated, the inked surface being rolled on the card which is to receive the impression.

FIG. 13.


Main DROITE : Impression successive et roulée des doigts :
Pouce
Index
Medius
Annulaire
Auriculaire
Dressé à
10 février
MAIN GAUCHE Impression successive et roulée des doigts :
Auriculaire
Annulaire
Medius
Index
Pouce
Fiche de 146 × 146 à classer anthropométriquement pour les sujets non photographiés. — Modèle 1904. — Série 1

Specimens of finger prints.

It is only the cuticle of the phalanges at the extremities of the digits of which a print is made.

In classifying the finger prints in the anthropometric files, use is made of those of the right hand only, and only of the first four fingers of that hand, viz., the thumb, index, middle, and ring finger. The little finger generally shows papillary patterns similar to its neighbor. Of course this resemblance is never complete, but for purposes of classification it is found expedient to refer only to the first four, which furnish enough combinations or "digital formulas" to enable the operator to sort the record-slips in the anthropometric boxes.

Where it is probable that marauders have touched the varnished furniture, or mirrors, or glassware, or objects covered with glossy paint, it is usual to attempt to discover their finger prints by dusting the surfaces with fine graphite (plumbago) or finely powdered white lead. In the first case the black powder will be fixed by the trace of greasy matter on the ridges of the finger. By blowing on the surface the superfluous powder not attached to such traces will be removed, and a fair—sometimes very distinct—print will appear of the arches, loops, and whorls, of the owner of the hand. This is photographed at a magnification of 4, 6, 8, or 10 diameters, depending upon the distinctness of the impression.

In using white lead, after removing the superfluous powder by blowing over the surface, the latter is exposed to the vapor of ammonium sulphide, which causes these traces to become black and thus permits of a photograph.

An interesting practical application of this method is beautifully shown in the December, 1908, number of the French "l'Illustration" in connection with a mysterious murder case (Steinheil–Japy) which has been agitating the capital since last summer. In this instance the invisible net-work of greasy exudation from the papillary ridges of various hands which grasped a bottle of cognac has been traced to the possessors of these hands.

Certain rules have been adopted to facilitate the sorting.

1. The type "e" is so designated no matter on what finger it may appear.

2. The record of the index is always given by the letters which describe its patterns whatever they may be, "e," "i," "o," or "u."

3. On the prints of the thumb, the middle, and the ring finger the types "i," "o," and "u" are designated by "x."

4. When an amputation (partial or entire), a deep wound (old or recent) obscures the form and number of the digital lines, it is customary to class the print of the finger or fingers as "u."

Thus the record slip of a subject whose right hand was amputated would be classified in the digital formula as "u," "u," "u," "u" which would be changed according to the rules above described into "x," "u," "x," "x."

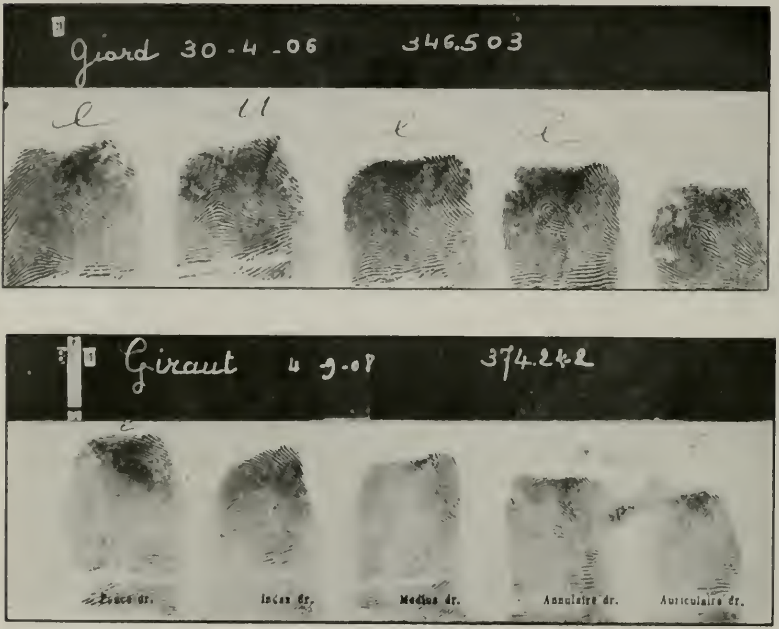
The 32 digital formulas or combinations of prints classified in the equally numerous anthropometric boxes are all obtained from the four elements "e," "i," "o," "u," and with the assistance of the four rules before mentioned.

e e e e	x e e e
e e e x	x e e x
e e x e	x e x e
e e x x	x e x x
e i e e	x i e e
e i e x	x i e e
e i x e	x i x e
e i x x	x i x x
e o e e	x o e e
e o e x	x o e x
e o x e	x o x e
e o x x	x o x x
e u e e	x u e e
e u e x	x u e x
e u x e	x u x e
e u x x	x u x x

Sixteen formulas beginning with "e"; sixteen with "x"; eight each with a second letter "e", "i", "o", and "u" respectively; sixteen each with a third letter "e" or "x"; and sixteen each with a final letter "e" or "x."

I asked M. Bertillon to give me the record finger prints of a case in which this one of his many methods had been used with success to identify a prisoner, to exhibit to this audience, and he gave me the record of which I have made a lantern slide. On the 30th of April, 1906, a man was arrested and measured, who gave his name as Giard. He was numbered 346,503. It should be mentioned that M. Bertillon pays no attention to the way his subjects for measurement may spell the names they give as theirs, but solely to the sounds or phonetic values, and this was set down as above given. On the 4th of September, 1908, a prisoner was measured and finger-printed, who gave his name as Giraut. He was numbered 374,242. During the two years and five months which had elapsed between the apprehension and measurement of these two prisoners 27,739 other prisoners had been subjected to the same ordeal in that place.

FIG. 14.



The search of files to discover whether this was an old offender brought in a few minutes this previous record. The agent in charge of the files went to the "e, u, e, e" case and produced a finger print which was compared with the second as you may compare them on the screen; the resemblance being so exact that it may be said no human being living or who ever did live could have produced the match to it. The man was identified at once.

Among the many names of criminals guilty of the atrocious Apache murders, highway robberies, parricide, and other horrible crimes which the daily Paris press recorded with disquieting regularity almost every day during September, I vaguely remember the name. He may not have been a murderer, but only the victim of a brain-storm during which he merely beat into insensibility and robbed his aged mother.

PHOTOGRAPHY.

The part of the service which has the most varied applications and which is directed by a most able assistant of M. Bertillon—M. David—is that of photography. In giving the general plan of the rooms devoted to the service of identification it was shown that the atelier, laboratories, and dark rooms are situated on the floor above that of the files and measurements. It is to this place that the subject of Bertillonage is brought after the osseous measurements, eye color, finger prints, and special marks are noted.

In the operating room, provided with all the necessary paraphernalia for regulating the light, is a little chair nicely pivoted on a small circular platform so that by touching a button the photographer can rotate it easily through 90 degrees, keeping the subject the while in perfect focus. The camera is fixed at the requisite distance to secure a negative one-seventh of nature. The subject is photographed so rapidly and with so little apparent effort that even the worst refractory has not time to think of distorting his features before he is photographed. But even if he maintain the most exaggerated distortion it will hardly perceptibly lessen the value of the print as a means of identification, for the features on which most stress is laid, the right ear and the nose, are not subject to movement at the possessor's will. Oftentimes indeed the attempt to disguise his features will result in bringing out some peculiarities of his anatomical structure which might otherwise have been missed.

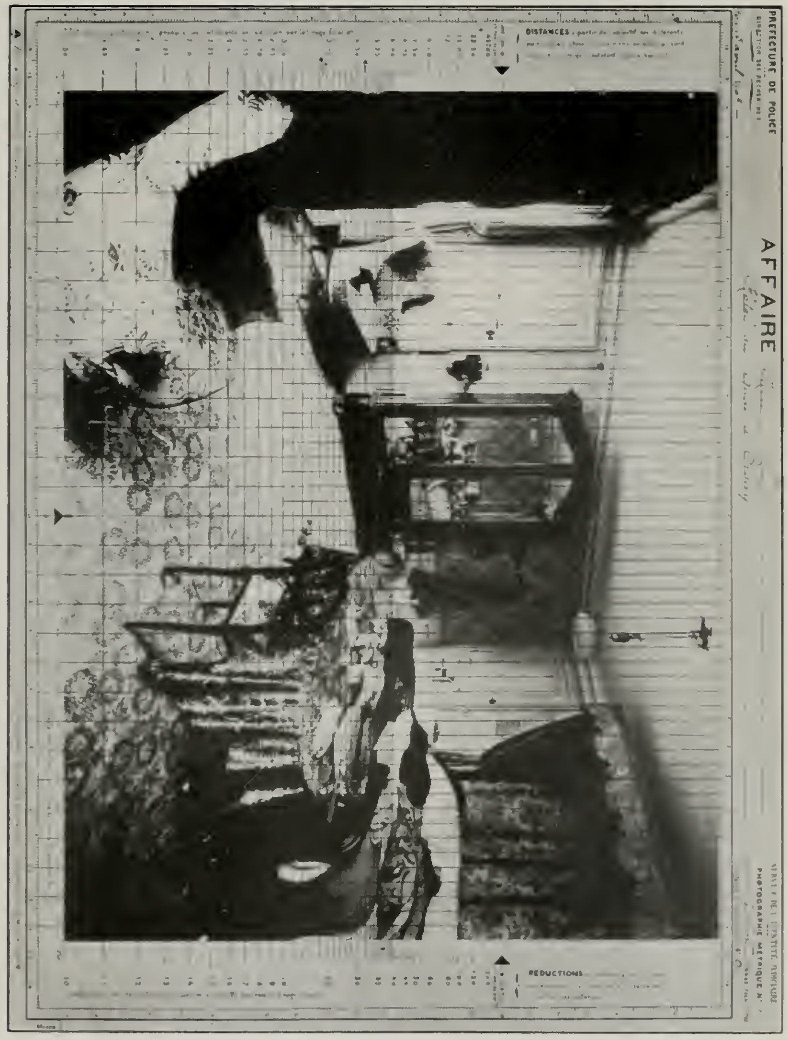
Equally as important is the use M. Bertillon makes of his carefully prepared camera in taking projections and pictures of scenes and places when it is necessary to know the distances of objects apart.

By an original improvement in the peculiarly French art of iconometric photography, modified and improved, called by M. Bertillon his Photographie métrique, an interior of a room is so printed from a single negative that one can immediately ascertain the direction and distance of any point in the picture to any other; which of course is of incalculable value to magistrates and juries trying to learn the facts and surroundings of some crime.

A masterly exposition of M. Bertillon's inventions of apparatus and application of the principles of descriptive geometry has just been issued by Dr. Louis Tomellini Privat Docent at the University of Genoa, called "Photographie métrique Système Bertillon," etc., Lyon A. Rey et Cie. 4 Rue Gentil. 1908, and sent to me from M. Bertillon's office.

> This illustrated pamphlet gives drawings and descriptions of the camera and accessories employed in the service of identification, and the portable automatic camera which enables any photographer to take metric photographs which may be employed to produce prints in which distances and directions may be measured. Both cameras may be used to take photographs in the ordinary method on a vertical plane, or reversed on the tripod with the objective lens directed downwards.
>
> The cameras are surmounted by two strips, one of which contains an eyehole and the other an aperture with cross-hairs, one of which is vertical and the other inclined 15 degrees with the horizon to adjust the oculo-tragian line. This arrangement produces the photograph of a subject, profile and face, at a reduction of one-seventh. A battery of objectives, prepared from M. Bertillon's indications, is called "of uniform impressions," with 10 cm. as its large angle. This battery is composed of three combinations obtained by changing the front lens. Combination N° 1 gives the maximum distinctness at 1.50 M. distance of the objective from the object; N° 2 at 2.50 M. distance, and N° 3 from 5 metres to infinity. Besides these, there is an aplanatic objective with a focus of 25 cm.
>
> With the objective of 25 cm. focus the descriptive photograph is taken and printed to one-seventh natural size; the distance between the objective and the eye of the subject being two metres, conformably to the rules prescribed by M. Bertillon for his service.
>
> The method for ascertaining distances and directions in these photographs is amply explained and illustrated in this pamphlet.
>
> Stereometric photography is one adaptation by M. Bertillon which permits accurate measurements without determining the heights of the points of the object photographed (more frequently a corpse) above the floor. Two photographs are taken, the one, with the objective of the camera directed downward, the objective 1.65 M. above the floor; the other is a lateral view taken horizontally with the camera 15 cm. above the floor. The mean reduction of the view taken with the optical axis perpendicular to the floor is one-fifteenth because it is assumed that the medium plane of object (if a human body) will be 15 cm. above the floor and at 1.50 M. from the object photographed.
>
> The following notes on iconometric photography, which is not the same process, by the way, but an older and in some respects inferior, are taken from the classical work of J. A. Flemer. "An elementary treatise on photographic methods and instruments," etc., John Wiley & Sons, London, Chapman & Hall, Limited, 1906.
>
> "Under iconometry we understand the measuring of the dimensions of objects from their perspective views (Bildnisskunst).
>
> "It refers to the plotting of terrene forms directly on the plotting sheet from the photographs of the landscape.
>
> "If a photographic perspective of an object, the focal length ('distance line'), the second nodal point ('principal point') of

FIG. 15.



Metrically-photographed room of a recent murder on the Quai d'Orsay, where the actual distance and direction of every object in sight from every other object may be accurately ascertained.

the camera lens, and the horizon line of the perspective are given —if the point of view and the central projection of an object are given—these data will be insufficient for the determination of the object with reference to position and size.

"If, however, *two* such perspectives of the same object obtained from two suitably located stations be given, the dimensions of the object and its position with reference to the two stations may be determined iconometrically, very much in a manner analogous to that in which a point is located (by intersection or by the so-called radial method) on the plane-table sheet by being observed from two known plane-table stations. * * *

"The instruments for this purpose are called 'Photogrammeters' and the Art 'photogrammetry.'

"The foundation of what has now developed into a most important kind of automatic surveying by means of the camera, were laid by J. H. Lambert of Zürich in 1759, but found no echo in practical application till 1791–93 when Beautemps-Beaupré applied it while on a scientific expedition on the shores of Van Dieman's Land (Tasmania). On returning to France he attempted to construct topographic reconnaisance maps of the coastal regions from his free hand sketches.

"Long afterwards Capt. Le Blanc of the Engineer Corps in the French army employed it for military purposes.

"In 1839 while alluding to the details of the daguerrotype process before the Chamber of Deputies in Paris, Arago spoke of * * * 'les moyens rapides d'investigation que le topographe pourrait emprunter de le photographie' (the rapid means of investigation which the topographer could borrow from photography) * * *

"Gay Lussac expressed himself similarly.

"The first serious application was made by Col. A. Laussedat in 1850. Since then Capt. E. Deville, Surveyor General of Mineral Lands, Ottawa, Canada; Dr. W. F. King, Ottawa; Signore L. P. Paganini, Engineer Geographer of the Military Institute in Italy; Dr. R. Doergens, Royal Technical High School, Charlottenburg, Prussia, have done extensive work with the system. Mr. Flemer gives a partial bibliography of this subject:

"La Fototopografia in Italia, L. P. Paganini, Rivista Marittima, 1889.
"Nuovi Appanti di Fototografia id., 1894.
"Zeitschrift für Vermessungswesen, Stuttgart.
"Zeitschrift für Instrumentenkunde, Stuttgart.
"Lehrbuch der prakitschen Photographie, Dr. A. Miethe.
"Anthony's Photographic Journal.
"Die photographische Messkunst, Prof. E. Schiffner, Halle, 1892.
"Die Anwendung der Photographie in der prak. Messkunst, E. Dolezal, Halle, W. Knapp, 1896.
"Die Stereo-Photogrammetrie, Maj. von Auek. Mitth. des k. k. Mil-Geograph. Inst. XII, 1903.
"Photographic Surveying, E. Deville, Ottawa, 1895.
"Photogramatrie und Internationale Wolkenmessung, Dr. C. Koppe, Braunschweig, 1896.
"Comptes Rendus d l'Acad. de Sciences, Paris.
"Annales de l'Observatoire Métérologique du Mont Blanc, J. Vallot, Paris, 1896.
"Recherches sur les Instruments, les Methodes, et le Dessin Topographique, Col. A. Laussedat, Paris, 1898."

CLASSIFICATION OF DAILY SUBJECTS.

Of 80 to 100 individuals brought every day to the service of identification for measurement, 12 or 15 per cent. are women, and 5 per cent. under the age of 16.

Half of the number are old offenders who have already been measured; and for them it is only necessary to identify them, *i.e.,* to be assured that they correspond with this or that condition of life previously avowed, and are not usurping some other. The women do not take off any of their clothing and the osseous measures taken of them are in the first place less numerous than those taken of men, and in the second place are so chosen that the clothing does not at all impede the measurements.

The descriptive record of a man consists of—

1. The anthropometric, containing eleven osseous measures.
2. The data needed for the "portrait parlé."
3. The observations of special marks, cicatrices, etc.
4. The finger prints.
5. The photograph of full and side face at a reduction to one-seventh nature obtained by a special camera with automatic action.

WOMEN.

The description of a woman is composed of about the same elements as that of a man, except as to span, body measure, length and breadth of head (on account of the coiffure), of the foot, and of the elbow, altogether six measures less than for men. The reasons for this have been already intimated. For the same reasons particular marks of the breast, the back, forearm, and arm, are not taken. The measurer confines himself to such marks as are uncovered and visible on the face, the back of the hand, the fingers and the palm, up to the articulation of the wrist. So far as concerns the photograph, the finger prints, the portrait parlé, or the descriptive record, the procedure is identical with that followed for men. Although the osseous measures taken of the skeleton are less numerous for women than for men, yet the method of classification is as perfect for one sex as for the other.

In general it may be said that one can take almost an infinite number of osseous measurements from the skeleton of a subject, but not all with equal facility. Besides this there are measures which though very valuable for purposes of identification offend against the sense of delicacy, and for that reason are rejected.

The present selection by Mr. Bertillon of parts to measure for anthropometric identification is recognized by the highest authorities in medicine and anthropometry as the best to combine ease of observation with the necessary importance for the object in view. It is fully admitted also that these selected measures are almost unchangeable from adult age to death.

PORTRAIT PARLÉ.

But the creation of M. Bertillon which is at once the most original and the most useful; which transforms in a few moments an ordinary guardian of the peace in a distant part of France by means of a telegraphic despatch into a detective agent able to recognize on sight a disguised malefactor whom he has never seen; the gem of the whole intricate system of Bertillonage is the "portrait parlé," or picture of essential features described in words.

To accomplish this a large code of abbreviations is necessary and a key to the meaning of the terms. Some of the most important of them have already been mentioned, but a word in explanation of their origin may be interesting. M. Bertillon thoroughly appreciates the value of a secret language known only to his operators, to stimulate their interest and to make of them a class apart. It is well too that his terms and methods should be concealed, as much as possible, from the criminal classes, which contain many bright minds that would take pleasure in thwarting him if they thoroughly understood all the observations on which he must perforce rely in his "instantaneous recognitions." Besides it is a short-hand which is rapidly written and translated.

He accomplishes three purposes in introducing and teaching to the police agents a kind of argot or dialect based upon abbreviations. He saves time and space, and he adds mystification to his work.

The thieves of every country have an argot or secret language, and it is advisable that the thief catchers should enjoy the same advantage.

But he spices this secret tongue with little catch-words which serve to fix the terms on the memory. For instance, a small oblong pamphlet printed exclusively for the French police but of which he was good enough to give me a copy has the following title:

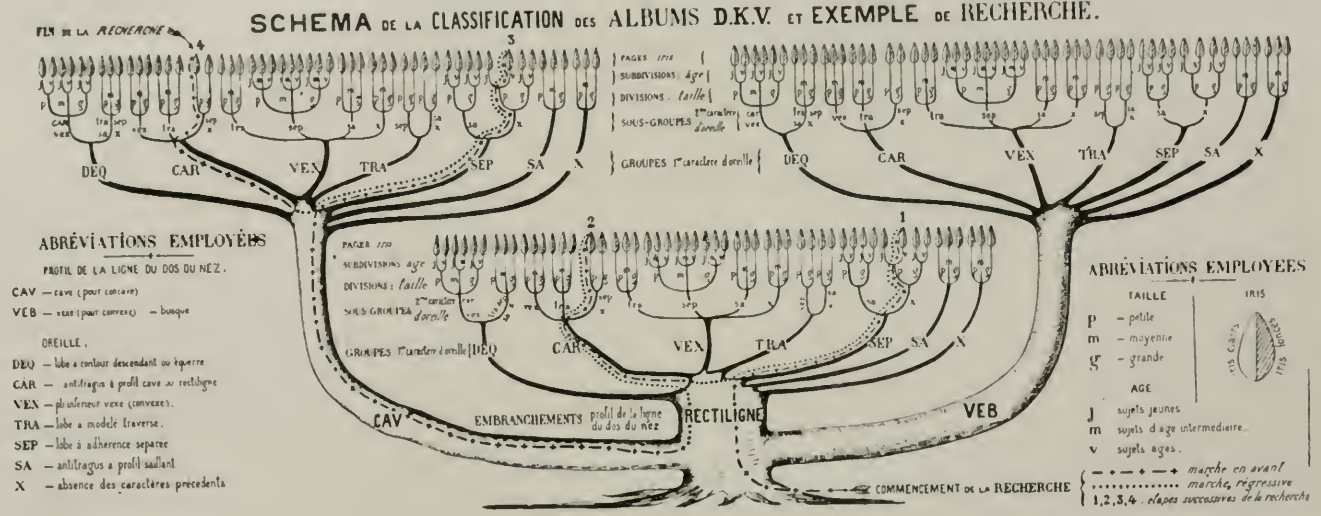
"Superintendency of detectives.—Service of judicial identification. Album D. K. V. of individuals subjected to interdiction of residence, escaped prisoners, and those sought for. Photographs at the Préfecture of Police, up to January 1, 1906.—Paris, Préfecture of Police, May, 1906."

> The D. K. V. is a play upon words and is an allusion to three of his principal modes of dividing the description of the ear, viz.:
>
> D-EQ, C-AR, VEX, which, he says, pronounced in succession, make three syllables, like Dé-ca-vé.
>
> The first syllable D-EQ is composed of two parts—D-, descendant (descending), and Eq, Équerre (square, right angle). These are applied to the lobe of the ear, and are the two opposite extremes of the first characteristic which is observed.
>
> C-AR is composed of the first two letters of "cave" for concave (concave), and R, rectiligne (straight); which are the two extremes noted in the possible position of the antitragus or interior border of the ear above the lobe.
>
> VEX is for convex and only one of the characters used to describe the "pli inférieur" or interior vertical edge (antihelix) of the ear, the other being of course concave as with the lobe of the ear. But the syllables put together make the word décavé, a term used in gambling when a player has lost his entire "cave" or pile, and is said to be décavé, or "cleaned out."
>
> It seldom is applicable to the subjects for whom the system was invented, for they are usually fleeing with the possessions of others who, if living, are better examples of the décavés or depleted.
>
> VEB is used for the equivalent of convex when the description is of the nose, because here M. Bertillon used two designations, one VEX (convex) for slightly aquiline, and busqué (hooked) for a very marked arch. He combines these two words by their initials VE- for vex and B- for busqué and calls the feature VEB.

A diagram illustrates the manner of searching in the album D. K. V. which may contain 3000 to 4000 photographs, for the identity of some suspected person whose nose, ear, height, apparent age, and eye color have been observed.

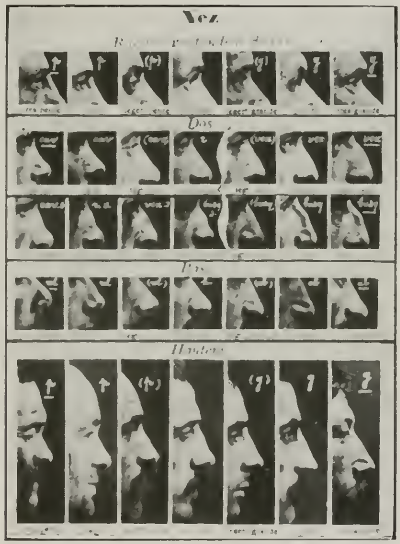
It represents a short-stemmed, low trunk with three principal divisions representing a concave, a straight, and a convex upper line of nose. It derives two characteristics from the ear affecting, first, the lobe, second, the lower fold or inner posterior vertical ridge. It then takes the height, the apparent age, and the color of the iris—six characters in all.

FIG. 16.


SCHEMA DE LA CLASSIFICATION DES ALBUMS D.K.V. ET EXEMPLE DE RECHERCHE.
FIN DE LA RECHERCHE
1
2
3
4
PAGES iris
SUBDIVISIONS âge
DIVISIONS : taille
SOUS-GROUPES 2me caractère d'oreille
GROUPES 1er caractère d'oreille
p
m
g
car
vex
tra
sep
sa
x
DEQ
CAR
VEX
TRA
SEP
SA
X
EMBRANCHEMENTS profil de la ligne du dos du nez
CAV
RECTILIGNE
VEB
COMMENCEMENT DE LA RECHERCHE
ABRÉVIATIONS EMPLOYÉES
PROFIL DE LA LIGNE DU DOS OU NEZ.
CAV — cave (pour concave)
VEB — vexe (pour convexe) — busque
OREILLE.
DEQ — lobe à contour descendant ou équerre
CAR — antitragus à profil cave ou rectiligne
VEX — pli inférieur vexe (convexe).
TRA — lobe à modelé traverse.
SEP — lobe à adhérence séparée
SA — antitragus à profil saillant
X — absence des caractères précédents
ABRÉVIATIONS EMPLOYÉES
TAILLE
p — petite
m — moyenne
g — grande
AGE
j sujets jeunes
m sujets d'âge intermédiaire
v sujets âgés.
IRIS
iris clairs
iris foncés
— • — • — • marche en avant
.... marche régressive
1, 2, 3, 4. étapes successives de la recherche

This D. K. V. work is simply perfected detective work and is merely preliminary to the more careful research of the "cabriolets," as the rolling boxes in the anthropometric file rooms are called, for such indications as preclude the possibility of a mistake in identity. The D. K. V. albums, I presume, are manifolded and supplied to the principal French cities and especially those on the frontier, while if the escaping convicts have been measured, each of a number of agents of the police situated near the frontier is furnished with a small folded card, such as will be shortly shown to you, giving his physical description.

FIG. 17.



NOSE (See Fig. 17)

DEPTH OF ROOT

very small	small	rth small	medium	rth large	large	vy large

RIDGE

very cave cave sin	cave rect sin	rth cave vex sin	rectil arched sin	rth vex sl arched	vex arched	very vex much arched

BASE (TIP)

very pug	pug	rth pug	hrzn	rth depr	depr	much depr

HEIGHT

very small	small	rth small	medium	rth large	large	vy large

PROTUBERANCE (See Fig. 18)

very small	small	rth small	medium	rth large	large	vy large

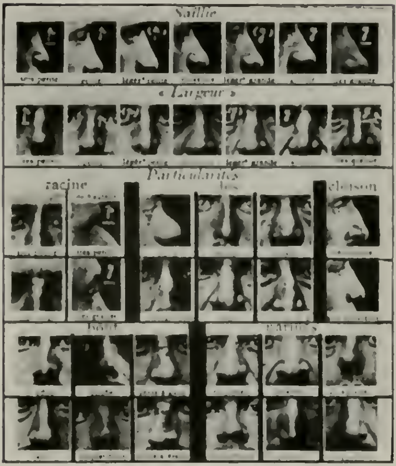
BREADTH

very small	small	rth small	medium	rth large	large	vy large

	ROOT		PECULIARITIES		RIDGE	
vy narrow vy broad	height vy small vy long	sigmoid (saddle) flat crv	thin broad	crushed cvd to 1	septum visible septum not visible	

	POINT				NOSTRILS	
thin large	bi-nodular end flat	incl left incl right		adh recur	dilated comprsed	flat l rt raised

FIG. 18.



RIGHT EAR—*General Diagram*

BORDER (See Fig. 19)

ORIGINAL BORDER-LENGTH

zero	small	rth small	medium	rth large	large	vy large

UPPER BORDER. BREADTH OF RIM

flat	small	rth small	medium	rth large	large	vy large

POSTERIOR BORDER. BREADTH OF RIM

flat	small	rth small	medium	rth large	large	vy large

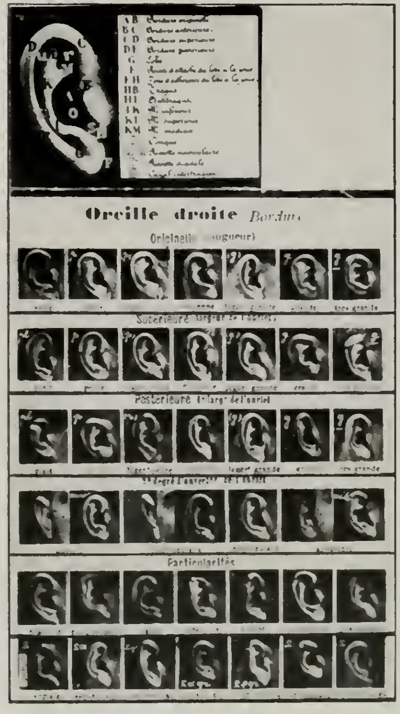
POSTERIOR BORDER. DISCONNECTION OF RIM

open	open	interm	interm	intermed	adherent	

PECULIARITIES

Nodosity	enla'ge'nt	protub	tuberc	crumpled	grooved	post sheared
sup pntd	sup-ant pntd	sup-post pntd	sup-ant square	sup-post square	sup bi-folded	sup-obt-ang

FIG. 19.



RIGHT EAR

LOBE (See Fig. 20)

CONTOUR						
incl downward	desc forms square	square	square inter (?)	square intdesc	intermediate	gulf
ADHERENCE TO CHEEK						
sheared	sheared	sl shrd	interm	sl sep	separated	separated
MODELLING						
furrowed	furrowed	sl furd	interm	unified	eminent	
HEIGHT						
vy small	small	rth small	medium	sl large	large	vy large
PECULIARITIES						
bored	split	narrow	broad	dimpled	comma shpd	islet
oblique-intern		oblique	extern	anterior-torsion		post obl wrinkle

RIGHT EAR

ANTITRAGUS (See Fig. 21)

INCLINATION

horizontal	horizont	rth horiz	interm	sl oblique	oblique	vy oblique

PROFILE

concave	rect	sl rect	interm	sl protub	protub	vy protub

"RENVERSEMENT." Change of plane (?)

plane-twisted	intermediate	straight

VOLUME

zero	small	rth small	medium	rth large	large	vy large

PECULIARITIES			PROFILE	PECULIARITIES		
fusion with border	tragus pointed	tragus bifurc	combination inclination oblique horizontal	cave	rect	protub
incision post-ant	canal narrow	dimple naviclr pt		cave	rect	protub

FIG. 20.

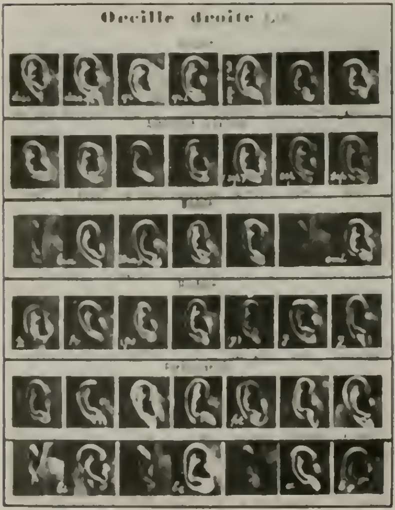
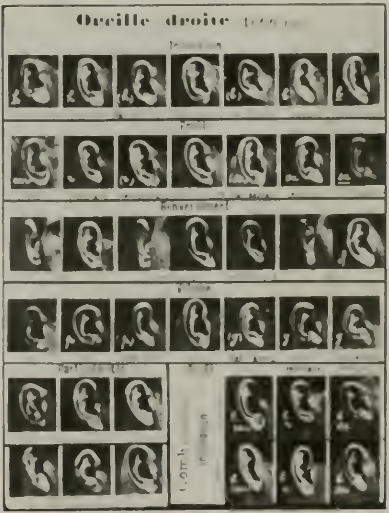


FIG. 21.



RIGHT EAR

FOLDS AND GENERAL FORM

LOWER FOLD

vy cave	cave	rth cave	interm	rth vex	vex	very vex

UPPER FOLD

zero	effaced	rth efcd	interm	rth mrkd	mrkd	very marked

GENERAL FORM

triangular	rectangular	oval	round

SEPARATION FROM SKULL

upper	back	lower	entire or pedunculous	at abv sep bel	brkn a'ry

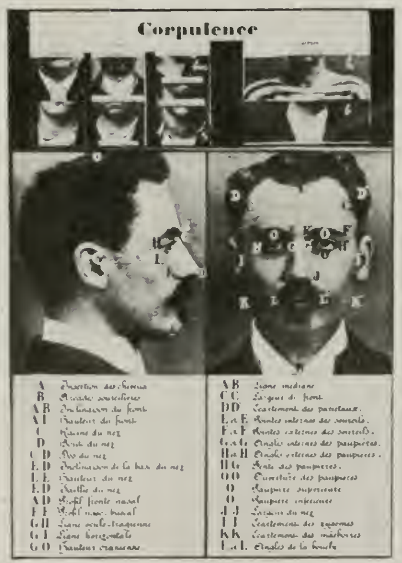
PECULIARITIES

up fld brnchd	un to brd	r hematome	mid fld hgh	orig contin	orig sep	inser vert
cnq low	cnq high	cnq nar	cnq broad	cnq trnd back	cnq trvsd	inser obt

CORPULENCE (See Fig. 22)

NECK		PECULIARITIES	SET OF SHOULDERS INCLINATION
short	thin	larynx prominent	horizontal
long	fat	double chin	oblique
		goitre	

FIG. 22.



HEAD AND FACE—*General View*

GENERAL CONTOUR OF THE HEAD

VIEW OF THE PROFILE. PROFILE FRONT-NASAL

contin	brkn	paral		ang	arched	undul

PROFILE NASO-BUCAL					SYNTHETIC	
prtb dentl	nose bone protub	up progn up orthgn	low progn compl orthgn	compl progn inwd cav		half moon pinion

HEIGHT OF CROWN				CRANIAL PECULIARITIES		
low	high		flat ocpt	rnd ocpt	tufted	keel shpd

VIEW OF THE FACE

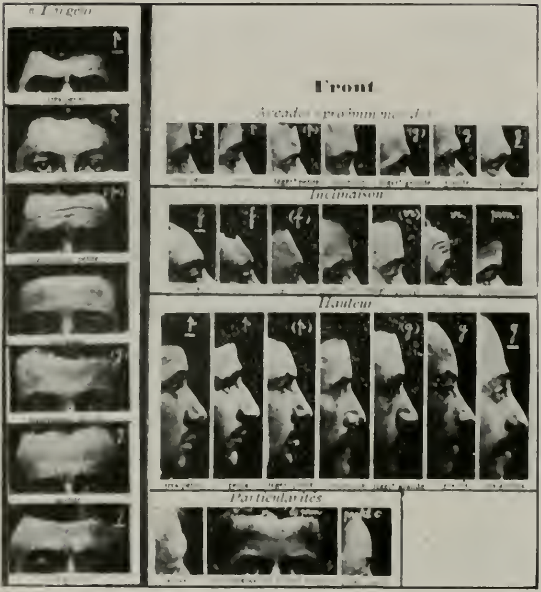
SYNTHETICALLY

top slip square	lozng broad	pyram round	bi-cave rectang	asym long

ANALYTICALLY

sep pariet comprsd par	sep zygom comprsd zyg	sep jaws comprsd jaws	chk bns prtb flabby chks	full face bony face

FIG. 23.



HEAD

FOREHEAD (See Fig. 23)

ARCHES OF EYEBROWS

very small	small	rather small	medium	rather large	large	very large

INCLINATION

vy rtrng	rtrng	rth rtrng	interm	rth vert	vert	prominent

HEIGHT

very small	small	rather small	medium	rather large	large	very large

PECULIARITIES

sinus		promin of temples	curved profile	

BREADTH

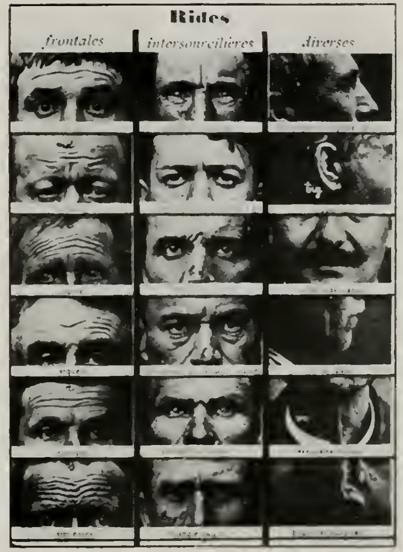
very small	small	rather small	medium	rather large	large	very large

HEAD

WRINKLES (See Fig. 24)

FRONTAL	BETWEEN EYEBROWS	VARIOUS
entire	vert and medium	temporal
medial	vert unilat l	tragian
curved	oblique to r	naso-labial
arched	hzl fr root of nose	jugular
rectil	circumflex	vert on neck
sinuous	triangular	occip pad

FIG. 24.



HEAD

EYEBROWS (See Fig. 25.)

SETTING	FORM	PECULIARITIES OF IMPLANT
close together	much arched	sparse
separated	rectilinear	sparse in tufts
low	sinuous	profuse
high	short	joined together
direction	long	maximum in tufts
oblique inwardly	narrow	bushy
oblique externally	broad	painter's brush

HEAD

EYELIDS	EYEBALL		SOCKETS
dimensions of opening	peculiarities	protuberant	
	HORIZONTALLY		
small large	eyes bridled up l falling	small deep set large protub	high low

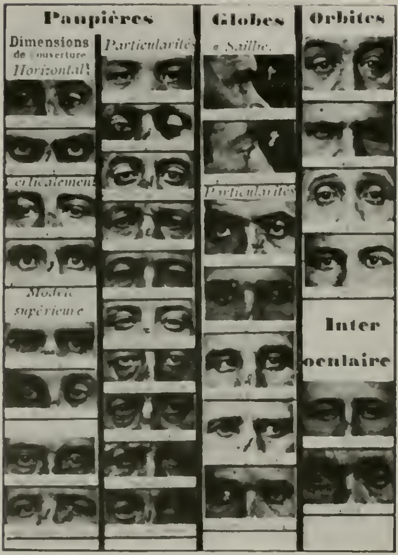
VERTICALLY

small slty opened large very open	extern extrusion compl extrusion	peculiarities much raised	deep full

UPPER

modelling covered apparent extern ang dprsd	lower as pads lower as pocket low wrinkled r reversed	strbsm converg strb r converg strb l divg	interocular small large

FIG. 25.



HEAD

CHIN

INCLINATION		HEIGHT	
retreating	protuberant	small	large

BREADTH		PECULIARITIES	
small pointed	large square	flat	crested

PECULIARITIES

dimple	long dimple	bi-nudular	prom furrow	above chin

HAIR

FRONTAL INSERTION	BALDNESS
circular rectangular in points mounting	frontal temporal fronto-parietal

HEAD

LIPS

NASO-LABIAL	HEIGHT		PROMINENCE	
small	large		upper	lower
		BORDER		
small	large		small thin	large thick
LACK OF ADHERENCE			PECULIARITIES	
up turned up	low pend	med trough prom	cracked	cic hare lip

MOUTH

		DIMENSION		
small	large		pinched	open

PECULIARITIES			
corners raised	corners depress	r corn dprsd	oblique to r
SYNTHETICALLY		DENTITION	
heart shnd mouth	thick lipped	incisors visible	incisors protub

This most important branch of the French police work is thoroughly prepared and brought to a high state of efficiency. In one of the suites of rooms in the Palace of Justice set apart to the service of identification is a rostrum with blackboard and mounted sheets containing life-size photographs of the types which are here presented.

There are three courses of instruction annually, each lasting three months, and consisting of thirty lessons of an hour and a half each. All the policemen of the prefecture of police, of the general safety, and of the ministry of the interior are obliged to complete this course in order to obtain their appointments.

The examinations at the end of each course are threefold: first, written, second, oral, third, practical test in the courtyard of the préfecture.

Besides the policemen taking this course are many physicians, lawyers, municipal guardsmen, republican guardsmen, judges, and many foreigners.

M. Bertillon has adopted as the motto of this school of instruction, and caused it to be painted on the rear wall, the following aphorism of his father.

"The Eye Sees in Objects Only What it Regards There, and it Regards Only What is Already in Idea in the Mind."

The practical exercise at the beginning of the course of description consists in trying to find among sixty small photographs the one or more which may be coupled with one of six life-size heads which the professor places in front of each scholar. The six large photographs have striking resemblances to certain of the smaller photographs, though their respective subjects were entirely unrelated.

The scholars always fall into the trap laid for them at the first trial which impresses upon them the necessity of depending upon the scientific method in drawing their conclusions. On the first trial the erroneous judgments are quite 80 per cent. At the conclusion of the course *there is not a single one made.*

At the commencement of the course, ignorant of the organs which should be scrutinized, and of the different points of view from which they should be examined they rely on striking resemblances, and on characters without value, such as the beard and the hair which the razor or the scissors can entirely change in an instant.

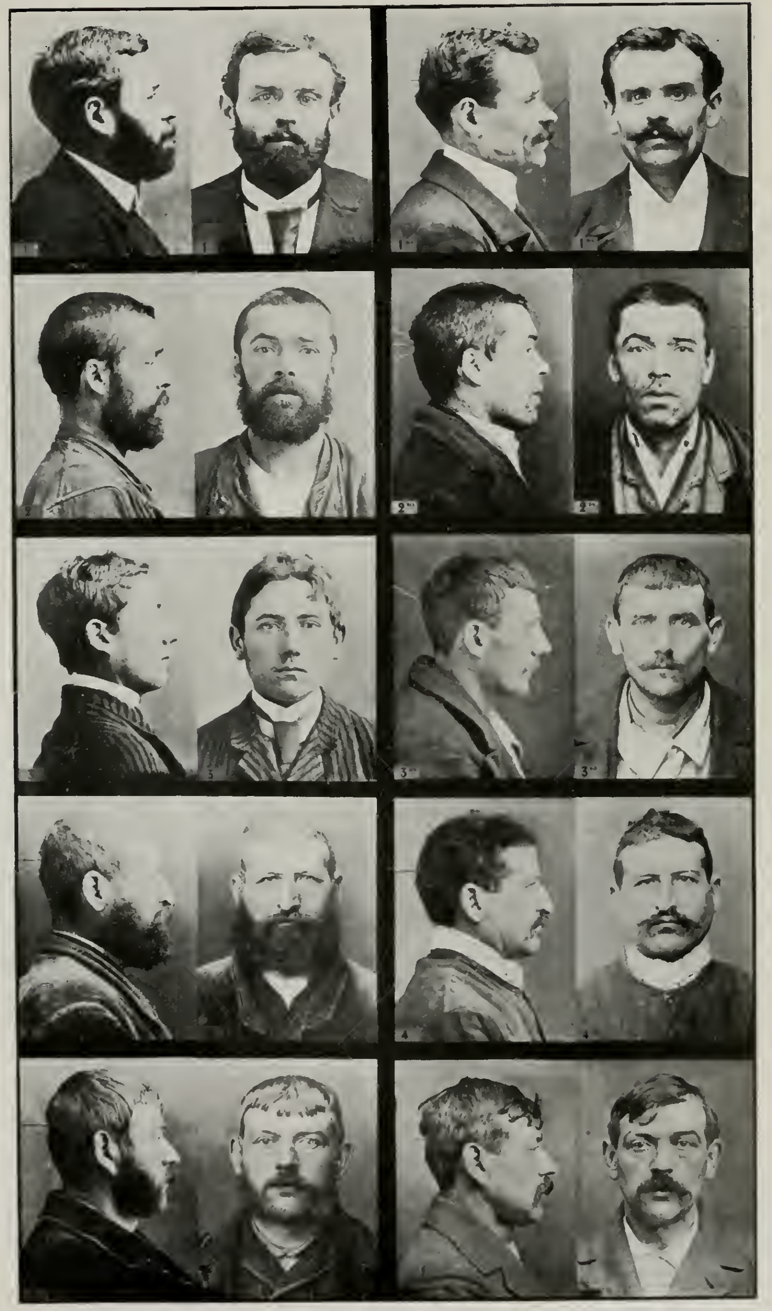
In the collection of sixty small photographs are two or three which ought to be connected with each of the large heads, but they are always missed at the commencement of the course because superficially they are so dissimilar in general aspect.

As an example of the changes to be expected after the lapse of a few years in the general appearance of an individual of the criminal classes the subjoined pictures are very instructive. It must be remembered that in Bertillonage the unit picture is the profile and full face, which are always coupled together.

It will be observed that each couple has a number affixed to some part of the picture, those of the left-hand double column having simple numbers and those of the right hand double column having numbers to which is attached " bis." If each couple were detached from the rest and lying on a table with sixty other detached couples, it is very improbable that any one could, by the usual method of superficial appearance, join to each of the five numbers of the left-hand double column the couple which represented the same man a few years later. But by the application of the Bertillon method the task is easy. Every couple of this series in the left-hand double column is of an individual who is represented a few years older on the same line in the right-hand double column, the photograph bearing the same number " bis."

The double couple marked " Job " and " Malib " is even more remarkable. The left-hand couple represents the appear-

FIG. 26.



ance of prisoner 264,338 on July 18, 1896. The right-hand couple represents the same man as 314,915 on Nov. 22, 1901.

The last double couple is still more remarkable. The left-hand couple represents one Péron arrested Nov. 28, 1897, and numbered 280,032; the right-hand couple represents Taran, an entirely different person, arrested the same day and the fourth person photographed after the negative of Péron was obtained. There is no relationship between them yet the general resemblance is striking. Any supposed identity immediately disappears if one scan closely the profiles of the noses and the structure of the ears.

FIG. 27a.

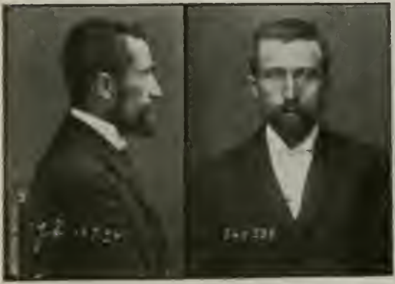


FIG. 27b.

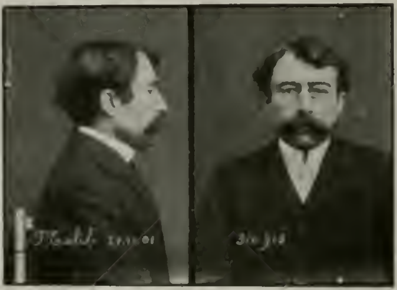


FIG. 28a.

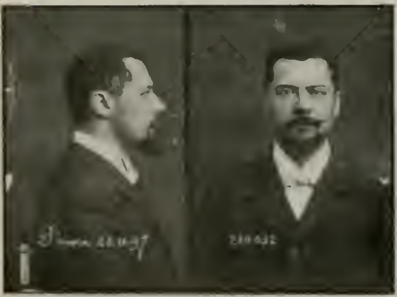
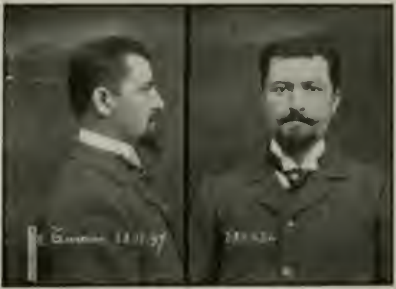


FIG. 28b.



The illustrated lectures and quizzes are conducted by M. Bertillon's representative, M. Marius Bertrand.

In addition to learning the anatomical names of the regions of the body employed in measurements, the meaning of very small, small, slightly small, medium, slightly large, large, and very large, as applied to the parts or the whole of these parts, they are instructed in the work of identification by means of a large number of " carte-de-visite " photographs which have been most ingeniously selected by M. Bertillon. These represent many score of individuals and among them the same person undisguised and in one or more disguises; with and without beard, moustache, hair on his head, etc. But there are other pitfalls for the unwary in the form of pictures of persons in no way related to each other and yet so like that the ordinary observer would hardly fail to call them the same person. Here is where a test is made of the efficacy of the lessons which M. Bertrand so carefully impresses on his classes: attention to the form and peculiarities of the nose, ear, height, age, and eye.

FIG. 29.

I was almost always deceived by the general appearance when a number of photographs were thrown on the table and I was asked to select two of the same person. Yet when these features in the two similar pictures were compared it was apparent that the contour of nose, or of ear, etc., were not alike, and on the other hand when the often very dissimilar-looking pictures of the same person were found for me I recognized a similarity in these little " ear marks " though the whole aspect of the face was so utterly unlike that I never should have suspected that the originals were the same person. The photographs taken for the portrait parlé are always a front and a side view; but the latter is of the greater value because in it one can determine the characteristics of nose and ear. The full face is important in those cases where there is no disguise and also to serve as a means of comparison where an ordinary photograph of a missing culprit can be obtained, because these ordinary photographs are usually full face or nearly so.

Another and still more useful practical exercise must be successfully accomplished in order that the policeman-scholar shall have a good rating. At the hour of noon a recess is taken by the employés of the Palais de Justice, and in a courtyard of the Palace of Justice the students of identification may be seen each carrying a little slip, the portrait parlé, and endeavoring to identify some colleague of which it bears the description. This is an ideal place and time to test the astuteness of the student-detectives.

FIG. 30a.

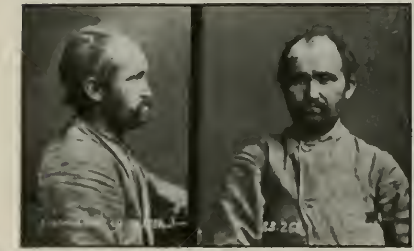
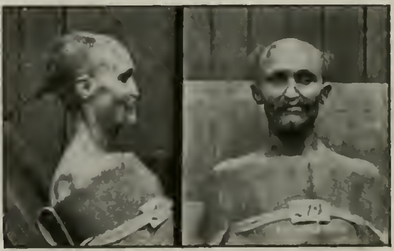


FIG. 30b.



To each of a class is given a portrait parlé of some other member who has been described for the purpose (often without his knowledge), and who it is known will be among the throng.

Each recipient of such a portrait parlé (without the photograph) is required to find the subject and to "arrest" him—at least to ascertain his name within the half hour. M. Bertrand informs me that though this is very difficult at first for the neophytes, in a very short time—a few weeks—they become so adept that scarcely a case escapes them. This of itself speaks volumes for the efficacy of the method.

Diagram of Recognitions made by the Service of Judicial Identification from 1883 to 1907 inclusive.

Number of recognitions of prisoners			Total number of recognitions
Years	In Paris	In the provinces or in foreign lands	
1883	49	....	49
1884	241	....	241
1885	425	....	425
1886	356	....	356
1887	487	....	487
1888	534	16	550
1889	538	24	562
1890	614	27	641
1891	600	41	641
1892	617	65	682
1893	527	65	592
1894	480	133	613
1895	414	153	567
1896	447	204	651
1897	371	218	589
1898	340	231	571
1899	363	264	627
1900	311	250	561
1901	389	288	677
1902	464	400	864
1903	361	418	779
1904	446	501	947
1905	456	517	973
1906	456	566	1022
1907	355	604	959
Total	10,641	4,985	15,626

Another and very valuable application of the records of the service of identification has been made in Paris for some years past, viz., the identification of the unrecognized dead in the morgue. There is a fatal connection between a life of crime and a death which brings the victim's body to the morgue, and it is often most valuable to the public safety to know when an unusually dangerous criminal is dead. A few days ago I received from M. Bertillon's office the profile-full-face picture belonging to the record of a criminal named Garraud who was arrested, measured, and numbered on Nov. 19, 1884, this being his first record of arrest. In April, 1900, an unknown body without papers in the clothing, or other means of identifying it was exposed in the morgue for the usual time without having been recognized by any of the visitors. The anthropometric service was then called upon to measure and photograph the corpse. With the aid of a few measures the clerk was able to find in the anthropometric file boxes a record slip with photograph bearing the number 83,268 (he was of the year 1900—219 at the morgue). The waif was recognized as Garraud, his history at that date was revealed, and the authorities of his district of Paris reported it to his relatives, who gave him decent burial.

The number of such recognitions in the morgue was in 1902, 10, 1903, 6, 1904, 3, 1905, 13, 1906, 19, 1907, 5, and 1908, 21.

Four squads of two agents each suffice to Bertillonize 100 persons before noon.

The criminals themselves are beginning to recognize the fact that it is useless to persist in asserting a false identity, and, if they have been measured before, frequently change the previous statement of their name and occupation on reaching the apartments of the service of identification before any measurement is *begun*. What facilitates this is a night of detention after their arrest and the consequent time to reflect.

> These cases have made an additional heading necessary in the files, which is called "recognized as having been measured before." They are entered thereunder as soon as their confession has been proved by a test with the head callipers. The number in this class actually exceeds those recognized against their will.

The latter show the number of persons who before the adoption of Bertillonage succeeded at their trials in masquerading as first offenders though in fact old offenders.

Another fact proving the efficiency of Bertillonage is the diminution of the number of persons recognized in prison as old offenders. Where there were 200 to 300 in number in 1884–85, in 1888 there were only 14, of whom ten had never been measured by the Bertillon system. Only 4 out of 31,000 succeeded in evading the vigilance of the Bertillon agents in that remote year, and there have been fewer ever since; so that it may be assumed that practically no one escapes the Bertillon scrutiny to-day.

MOTIVES FOR FALSIFYING NAMES.

The motives which induce old offenders to change their names are first of course not to have their past record in addition to their present offence to answer. Besides there are many who are deserters from the military service, or refractories who are especially anxious not to be relegated to the military authorities.

Certain kinds of criminals seem more inclined than others to give a false name. In the front rank, says M. Bertillon, are the Anglo-Saxon pick-pockets. All of these gentry think it necessary to lie about their identity. The result has been that since the establishment of the service, the number of pick-pockets arrested has constantly diminished. In 1885 it was 65, in 1886 it fell to 52, in 1887, to 34, and in 1888 to 19.

Many of the borrowed names are manufactured entirely and have no relation to any actual being. But among the names borrowed the greater number are the family names of the culprits' mothers before marriage. Others maintain their real surname but take the given name of a brother. In this case it is often found that data of many of the measurements closely approach those of the persons they have honored by selection to suffer for their sins; and cicatrices and special marks are relied upon to establish the actual fact.

It sometimes though less frequently happens that an evildoer arrested for the first time gives a false name, condition, and occupation, to avoid the scandal which would rest upon his family. And that leads to a proposition of M. Bertillon which is perhaps the most important suggested by his system.

If the identification be so perfected, and so universally adopted, that recognition of a person who has been Bertillonized is positively certain, will it not be possible to so modify the penal legislation that the trials and condemnations of criminals shall proceed to their ultimate punishment of the guilty without the use of names at all? In this way the innocent parents, brothers and sisters of a degenerate may be spared the added humiliation and suffering of seeing the name they bear, and have tried to make honorable, associated with some revolting or contemptible crime. Of what use from a penological point of view is it that Leon Czolgosz is published through the world as a murderer if the fiend who had that name has been caught, tried, condemned, and executed?

May not the discouragement produced upon a family of grown-up brothers and sisters who have been too long known in the community to renounce a name one of them has made infamous, lead to the descent of the others into crime?

Just as Newton's proof of the laws of the revolution of the planets was the result of putting together and combining formulas long before known; just as "Paradise Lost" was constructed by juxtaposing English words at the command of the poorest subject of the British Kingdom or Commonwealth; just as Napoleon's victories were won by putting into unwonted relations to each other the ordinary laws of war known since the time of Julius Cæsar; so M. Bertillon's service has been to construct out of old, well known materials the most powerful engine for the detection of criminals, and therefore the arrest of crime, which ever has been devised.

The extent of the debt to him of civilized communities is not lessened from the fact that like all engines this one needs careful and patient study by intelligent men to make it effective.

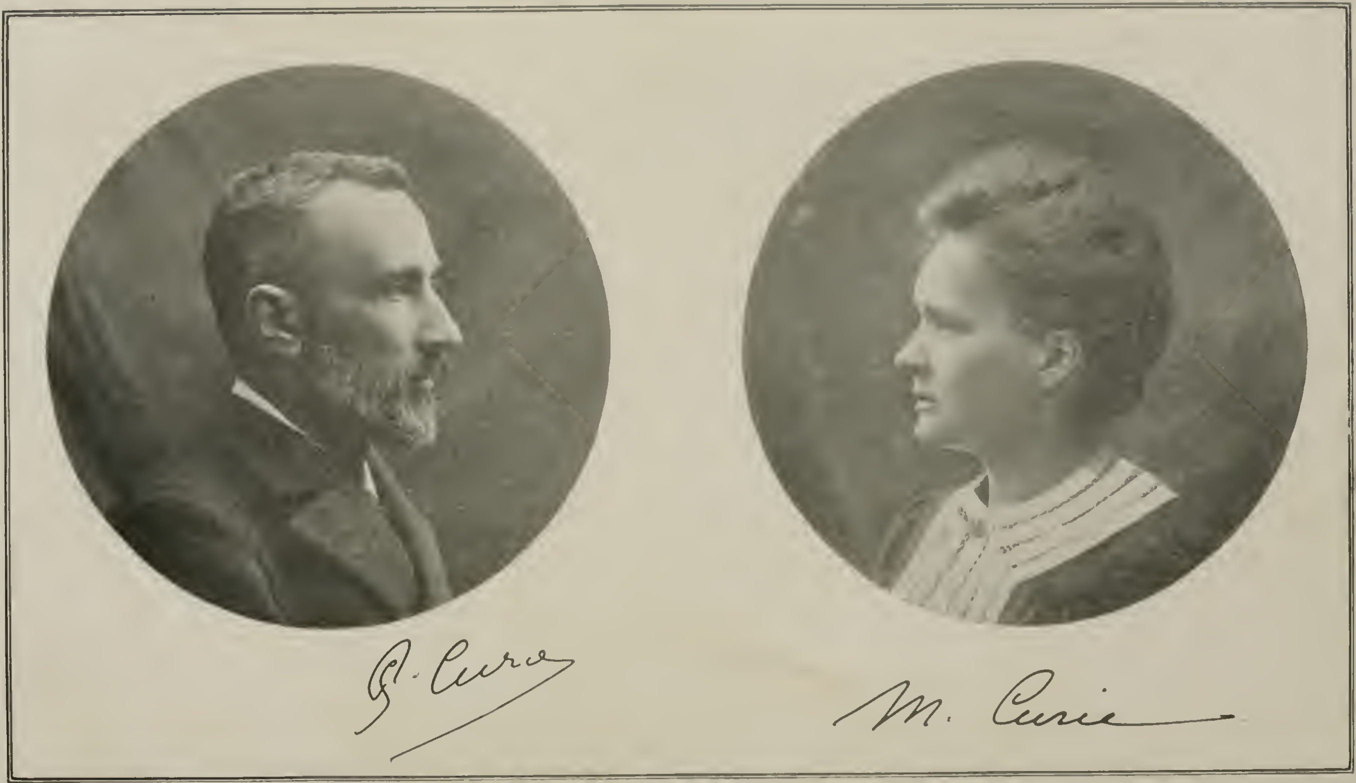
OVER-CUTTING OF CONNECTICUT'S FORESTS INDICATES GENERAL RATE OF TIMBER CONSUMPTION.

It has been estimated that the amount of wood annually consumed in the United States at the present time is twenty-three billion cubic feet, while the growth of the forest is only seven billion feet. In other words, Americans all over the country are using more than three times as much wood as the forests are producing. The figures are based upon a large number of State and local reports collected by the government and upon actual measurements.

The State Forester of Connecticut, in a recent report, has given figures on growth and use for New Haven County, which give many more valuable details than are generally to be obtained, and well illustrate how the forest is being reduced by over-cutting. In this county a very careful study was made on each township of the amount of forest, the rate of growth, and the amount of timber used. For the year 1907 the timber used was 120,000 cords, in the form of cordwood, lumber, ties, poles, and piles. The annual growth on all types of forest land, including the trees standing on abandoned fields, for the year, reached a total of 70,000 cords. Thus the amount cut yearly exceeds the growth by 50,000 cords.

The amount of standing timber considered as merchantable and available for cutting within the next few years was found to be 1,200,000 cords. Each year the annual growth increases the supply on hand by 70,000 cords, while the use decreases it by 120,000. The net reduction is therefore 50,000 cords a year. If the cut and the growth remain at the present figures, the supply of merchantable timber will be exhausted in about twenty years. At the end of that time there will be a large amount of forest standing in the county, but it will be in tracts under forty years of age, containing wood below the most profitable size for cutting. Cordwood could still be cut, but supplies of the most profitable products, like ties and lumber, would be practically exhausted.

Connecticut's case illustrates what is meant when the exhaustion of the timber supply is spoken of. It does not mean that every tree will be cut and that the ground will be bare. It means, on the other hand, that year by year the people of the country are cutting more timber than the forest grows, and that within a comparatively short time the continued loss will have so reduced the forest that it will be difficult and expensive to obtain timber of useful size in sufficient quantity.



P. Curie

M. Curie

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FRANKLIN INSTITUTE

THE DISCOVERY OF RADIUM.

[Report of the Franklin Institute, through its Committee on Science and the Arts, on the researches by which Professor and Madame Curie were led to the discovery of radium. Subcommittee: Harry F. Keller, chairman; William J. Hammer, George F. Stradling, Robert H. Bradbury, Arthur J. Rowland, H. Clyde Snook. No. 2413.]

The year 1895, in which were published Lenard's experiments on the cathode rays and Röntgen's discovery of the X-rays, may be said to mark the beginning of a new and most fruitful period in physical science. The first decade of this period will ever be memorable for great achievements, both in the discovery of new facts and in the framing of hypotheses, which have so materially advanced our knowledge of the constitution of matter. Among the experimental researches of this period none, perhaps, will stand out more conspicuously than those which have brought to light the carriers of radio-activity and which have culminated in the discovery and separation of that most powerfully radio-active element, radium. It seems hardly within the scope of this report to review, even briefly, the very numerous discoveries, made by a host of investigators working in widely different fields, which prepared the way for the experimental inquiries of Professor and Madame Curie; but the starting-point of these researches was the discovery in 1896, by the late Henri Becquerel, of those wonderful radiations which their discoverer called uranium rays, and which, under the more fitting name of Becquerel rays, we now regard as a manifestation of radio-activity.

A study of the phosphorescence of certain uranium salts, such as the double sulphate of ammonium or potassium and uranium, led Mme. Curie to undertake a systematic examination of other substances for Becquerel rays, and she found that thorium compounds also emit them. Quantitative determinations of the radio-activity of various uranium and thorium minerals then disclosed the fact that this property was not proportional to their uranium or thorium contents, and that some of the minerals were indeed several times as radio-active as the free elements. Having ascertained that the radio-activity of uranium is an atomic property, *i.e.*, a property not affected by combination with other elements, Mme. Curie argued that strongly radio-active minerals, like pitchblende, must contain some unknown substance of greatly superior radio-activity, and, joining forces with her husband, the late Pierre Curie, she proceeded to search for the hypothetical constituent. The Austrian Government aided the investigators by placing at their disposal a ton of uranium residues from the Imperial factory at Joachimsthal, and it was from this material that, by means of suitable analytical processes and guided by the extremely sensitive indications of the gold-leaf electroscope, the Curies succeeded in separating, first, the highly radio-active substance which they named polonium, and, later, in conjunction with M. Bémont, the still more active body which they so happily christened radium. Although other radio-active substances, notably Debierne's actinium and Boltwood's ionium, have since been extracted from uranium and thorium minerals by other investigators, radium still remains the only one that has been characterized as a chemical element, and, while it has not as yet been obtained in the free or elemental state, it has been isolated in the form of pure salts, such as the chloride, bromide, sulphate, and carbonate. Its analytical behavior and other chemical properties were found to be those of the alkaline earth family of elements, and its place in this group was confirmed by Mme. Curie's repeated determinations of its atomic weight, and by a careful study of its spectrum by Demarçay, Runge, and others.

In addition to the separation and investigation of the radio-active constituents of pitchblende the Curies have made a most elaborate study of the radiations of these bodies, of the various physical, chemical, and physiological effects which the latter produce on other substances and on living tissues, and of the tremendous energy which is manifested in the spontaneous transformations of radium.

The committee charged with the preparation of this report on Professor and Madame Curie's work on radio-active substances is of the opinion that it constitutes one of the classical researches in physical science, and that its principal result, the discovery and characterization of radium, is without doubt a scientific achievement of the first magnitude. This estimate the committee bases mainly on the following considerations, viz., in the first place, that only a bold scientific imagination could have conceived the idea of instituting the quest for an unknown radioactive constituent of the uranium minerals; secondly, that one cannot help but be deeply impressed with the brilliancy of the method of research which combined an entirely novel analytical agent—the ionization of air—with a masterful selection and combination of known chemical reactions; thirdly, that the work could not have been carried to its successful conclusion without the rare skill, the sound judgment, and the extraordinary perseverance displayed by the investigators; and fourthly, that the discovery of the carriers of radio-activity has placed at the command of scientists a new source of energy which has already been instrumental in opening up most fruitful avenues of research in a previously untrodden field. Without in any way detracting from the value of the splendid contributions to our knowledge of radio-activity which we owe to Rutherford, Elster and Geitel, Ramsay, Giesel, Soddy, Boltwood, and many others, it is safe to say that if it had not been for the epoch-making researches of the Curies, we would still be ignorant of the immensely powerful emanations of radium and thorium, of the transformation of radium emanation into helium, of the apparent degradation of elements of large atomic mass into others of smaller atomic mass, of the differences in the character and effect of the several kinds of radiations and emanations emitted by radio-active bodies, and, further, the numerous applications of radio-activity to biological, medical, geological, and cosmic problems which have been recorded, would not have been made in our time.

In view, then, of the invaluable services which Professor and Mme. Curie have rendered to science, the committee recommends that the highest award of the Franklin Institute, the Elliott Cresson Medal, be bestowed upon Mme. Sklodowska Curie of Paris, as a recognition of her share in this work, and as a tribute to the memory of her lamented husband, Pierre Curie, whose indefatigable co-operation so largely contributed to its success.

Attest: JAMES CHRISTIE,
Secretary.

PHILADELPHIA, January 6, 1909.

SECTION OF PHYSICS AND CHEMISTRY

(*Stated meeting held Thursday, December 10, 1908.*)

THE THEORY AND PRACTICE OF ILLUMINATION.

BY

THOMAS W. ROLPH.

In any branch of engineering, practice usually precedes theory. As practice develops and becomes more wide-spread, its faults show themselves, and in the attempt to remedy these faults the theory is evolved. Theory reacts upon practice, improving it, and practice in turn reacts upon theory, causing a development of shorter methods of predetermining results.

Thus, in the field of illumination practice is several thousand years old, but the theory is only beginning to be developed. The development of the early forms of illumination was not accompanied by any great increase in intrinsic brilliancy or intensity of light per square inch of lighting surface. The fire brand of the savage naturally led to the use of the pine torch for illumination. This in turn was succeeded by candles and oil lamps. Until the introduction of illuminants more efficient than these, the intrinsic brilliancy of the light-source remained very low. The quantity of light which could be obtained from a single light-source also remained low, and to illuminate large areas large numbers of light-sources were necessary. It was a simple matter to place these lights where desired. With the development of gas and electric lights, whose locations are more or less permanent, faults of location began to be apparent. Candles or oil lamps could be moved to the part of the room in which the light was wanted. For example in a bed room they could be placed near the mirror when it was in use. Generally speaking this is impracticable with gas and electricity, however, and in order to obtain the light at the proper points, it is necessary to either flood the room with light or to locate the lights where light is desired. The former is undesirable from the standpoint of economy, and hence arose the study of light location as a part of the work of the designer of lighting systems. Another important factor in the development of illumination was the decreased cost of the production of light, which led to a wider use and therefore raised the standard of illumination. Consequently the use of lights with regard to efficiency of operation and the placement of lights with regard to uniformity of illumination attracted the attention of the workers in the field.

At this point theory of illumination began to be developed. Methods of changing the natural distribution of light-sources were introduced; then methods of measuring the intensity of light and of calculating the amount of light necessary to obtain the required illumination, were brought out. The early calculations were necessarily laborious and were, therefore, not widely applied. Improvements have been made, but it is only within the last two or three years that these improvements have shortened the methods of calculations sufficiently to cause their widespread application. Conditions are now such that it is a commercial proposition to apply illumination calculations to practically every problem of any size. The conditions of lighting in this country are, therefore, gradually improving, although it is no exaggeration to say that over half of the lighting systems in use to-day could have their efficiency materially increased without in any way detracting from the artistic results obtained. This is due both to the increased efficiency of modern illuminants themselves, and to improvement in the location and equipment of them.

In considering the theory of illumination, we must first consider the purpose of illumination. Its principal object is to enable the eye to see comfortably the objects illuminated. Here at once we perceive two factors: first, the human organ upon which the effect is produced, viz., the eye; second, the factor which produces this physiological effect, viz., light.

Considering light first, it may be defined as those particular vibrations of the ether whose wave-lengths measure between .00004 of a centimetre and .00008 of a centimetre. The visible spectrum lies between these limits, the violet rays being the shortest and the red rays the longest. When the colors composing this spectrum are combined in about the same proportions, as in day-light, the effect upon the eye is that of white light. This is the combination of colors ordinarily striven for in artificial light-sources.

Light itself is invisible, and by this is meant that we cannot see light rays unless they pass into the eye. For example, the beam of a search-light would be absolutely invisible when viewed from the side, were it not for slight particles of dust in the air which reflect portions of this beam back to the eye. To see any object, then, we must have light falling upon this object and reflected from it to the eye.

Illumination as a branch of engineering is peculiarly distinctive inasmuch as it involves effects upon a human organ. To understand the problem, we must consider the construction of this organ. Fig. 7 is a rough drawing of the construction of the eye. It is similar to a camera. In the figure, *i* is the iris or diaphragm which forms the colored portion of the eye; *p* is the pupil, or opening through which light passes; *l* is the lens for focussing the picture; *r* is the retina and corresponds to the plate or film of the camera. The central portion is called the vitreous humor and consists of a transparent fluid filling the inner portion of the eye, and serving to maintain the shape of the eye. The action of both the lens and the iris is automatic. The muscles moving the lens automatically focus the object to be seen, upon the retina. In the eye this focussing is accomplished by changing the shape and consequently the focal length of the lens. In a camera the focal length of the lens never changes and focussing is accomplished by a change in the distance from the lens to the plate or film. The iris determines the amount of light to be allowed to pass into the eye. It corresponds to the stops of a camera. For example, when the light becomes very intense the iris automatically closes as far as possible. Photographers know that the smaller the stop in the camera the sharper the definition will be in the picture. This is also true of the eye. When the illumination is very low and objects are dimly lighted, the iris is open to its widest extent, to allow as much light as possible to pass in. The outlines of objects are then indistinct and hazy, showing that they are not focussed perfectly upon the retina. Brilliantly illuminated objects, on the contrary, stand out very sharply and distinctly. This does not mean, however, that a bright object such as a filament of an electric lamp would stand out distinctly, for here the brilliancy is so great that the iris shuts out as much light as it can, and yet cannot shut out enough to prevent a strain of the retina and consequently poor vision.

For the protection of the eye there are several points which should be considered in designing lighting systems. The following are the most common causes of injurious effects:

1. Too little light.
2. Too much light.
3. Glare.
4. Flickering.
5. Streaks or striations.
6. Extreme contrasts.
7. Reflection from polished surfaces.

The first two of these are easily taken care of by the calculations of the engineer.

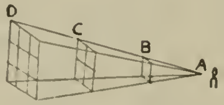
Glare is a common fault in lighting systems, and it has worked untold injury to the eye. Witness in theatres and public halls the many lighting systems with bare lamps directly in the field of vision and often so arranged that the audience must look past or nearly at them in order to see the stage or platform. Some of these systems of lighting appear to have been designed with the special object of adding to the prosperity of the oculist. Two simple considerations will be the means of eliminating these injuries. First, keep the light-sources as far as possible above the direct range of vision—no economy is sacrificed by this, if correct reflectors are used. Second, diffuse by a globe or reflector the light from sources of high intrinsic brilliancy.

It was previously stated that the action of the iris of the eye is automatic. In its motion, however, there is an appreciable time factor and a change in the intensity of the illumination on a surface does not cause an instantaneous change in the size of the pupil. Herein lies the injury worked by a flickering light-source, for before the eye can adjust itself to a given intensity of illumination, the intensity has changed. The most common example of flickering is the ordinary arc lamp.

Streaks or striations are caused by reflection from a polished metal surface. A polished aluminum reflector will produce brilliant streaks on a surface illuminated by it. The attempt of the eye to adapt itself to two conditions of illumination at the same time, cannot fail to be harmful.

An illustration of eye strain caused by contrasts is in the illumination of a book-keeper's desk. It is not uncommon to find a light source with a concentrating reflector, brilliantly illuminating one book, while another book continually referred to, is supposed to be illuminated by the same light. The quantity of light on either book may be sufficient for comfortable vision, but the necessity of a continual change in the size of the iris is a strain on the muscles. Reflection from polished surfaces is regular reflection. By regular reflection is meant the direct reflection of light. The extreme case of regular reflection is that of mirrors, but any glazed paper causes it and only a very rough surface, such as blotting paper, does not give some direct reflection. Unless the light is properly placed, this causes a brilliant spot on the paper worked upon, and consequent injury to the eye. In desk lighting this can be avoided by placing the light-sources not in the middle of the desk or directly in front, but at the left.

FIG. 1.

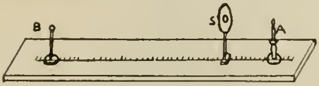


Law of inverse squares.

The desirability of obtaining the correct intensity and distribution of illumination and of obtaining this in an efficient manner, necessitates the use of lighting calculations. In considering these calculations, we must first consider the fundamental units of light and illumination. Of these, the most widely used is the candlepower or unit of intensity of light. It should not be confused with quantity or with any idea of distance. If a lamp gives a certain candlepower in any particular direction, the candlepower is the same no matter what the distance may be. It is not intensity of light, but illumination which is affected by distance from the light. The unit of quantity or flux of light is the lumen. A third unit in common use is the unit flux-density or intensity of illumination, and is the foot-candle. Flux-density varies inversely as the square of the distance from the light-source when the latter is a point. This is illustrated in Fig. 1.

The emission of light from a point may be considered analogous to a spreading stream of water issuing from the nozzle of a hose and affected by no other forces. Since there are no other forces acting, each particle will travel indefinitely in the same direction. Candlepower of light is analogous to the speed or velocity of the water. It is the same at all distances from the nozzle or light-source. Flux or quantity of light is analogous to the quantity of water which the nozzle sends out in a unit of time. This is also a constant quantity for any particular condition of flow. Flux-density is analogous to the quantity of water which would strike a unit of surface in a unit of time. For example, in Fig. 1 a unit of surface one foot from a point-source of light of one candlepower has a flux-density or intensity of illumination of one foot-candle. Two feet from the source of light, the surface over which the same flux of light is spread is four times as great, and the average flux-density is therefore only one-fourth of one foot-candle. We may, therefore, write the formula which is used as the basis of one method of calculating illumination

FIG. 2.



Principle of the photometer.

$$I = \frac{CP}{d^2}$$

where I is the flux-density in foot-candles, $C\ P$ is the intensity of light in candlepower and d is the distance in feet from the light-source to the point considered. Although rarely appreciated, the fact must not be over-looked that the candlepower, foot-candle, and lumen are essentially rates, and hence involve in themselves the element of time. For example, the lumen is defined as the quantity of light passing a unit area in one unit of time. Rates cannot be bought and sold but quantities can. Lumens, or that which is used to produce them—kilowatts, —cannot be bought and sold but lumen-hours or kilowatt hours can be.

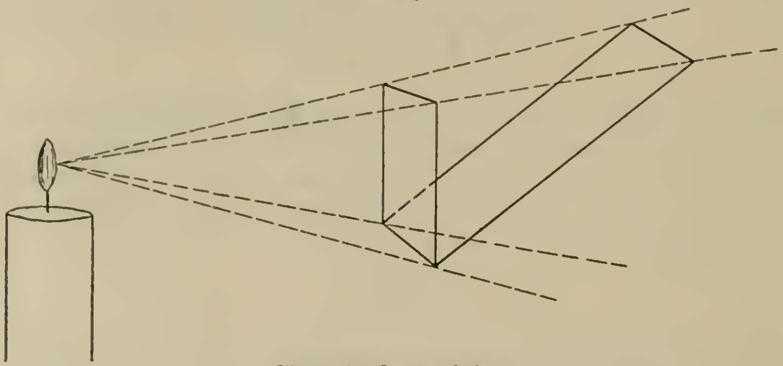
In deducing the equation given above, we have considered light striking a surface perpendicularly. When the surface is inclined to the direction of light, a given flux is spread over a larger area as illustrated in Fig. 3. The flux-density or illumination is therefore decreased and this decrease is proportional to the cosine of the angle. This is known as Lambert's law, and introducing it into the formula, we have

$$I_h = \frac{CP \cos \theta}{d^2}$$

where I_h is intensity of illumination on a horizontal plane as distinguished from a plane normal to the direction of the light rays, and θ is the angle which the ray of light makes with a line perpendicular to the horizontal plane.

This is the formula used for determining the flux-density or intensity of illumination in foot-candles at any point on a horizontal plane. The formula with θ equal to 0, forms the basis of the photometer or instrument for measuring light intensity. The measurement is accomplished by balancing the illumination from the light-source being measured, against the illumination obtained from a standard light-source and then introducing into the equation the squares of the distances from each light-source to the comparison screen. This principle is illustrated in Fig. 2 and forms the basis of practically all photometers, although the more elaborate instruments are complicated by various devices for obtaining precision and ease of operation. By means of the photometer we can obtain the candlepower or intensity of light of a light-source in any direction.

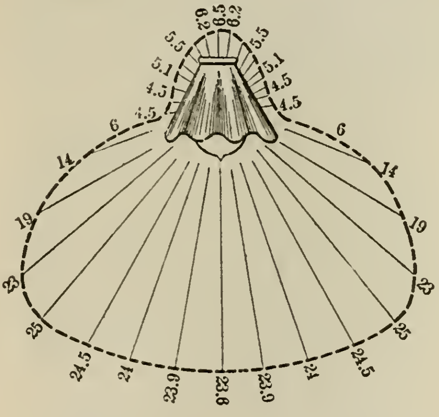
FIG. 3.



Illustrating Lambert's law.

Fig. 4 shows a photometric curve. This curve is found by a photometer and shows the candlepower of light in all directions, in a vertical plane, from directly underneath the light-source to the point directly above the light-source. In obtaining these values, the lamp and reflector were considered as a single point of light and since the comparison screen was at a distance of 10 feet from the lamp and reflector, the assumption of a single point introduces but little error. Fortunately, the intensity of light of most of our light-sources is the same in any direction in any particular horizontal plane. The distribution in a vertical plane, therefore, shows the intensity in every direction. Very slight errors are eliminated by making this a test in the mean vertical plane. To obtain these mean values, the light-source is rotated about its axis during testing at such a speed that each candlepower reading is the average reading for the horizontal plane in which it is taken.

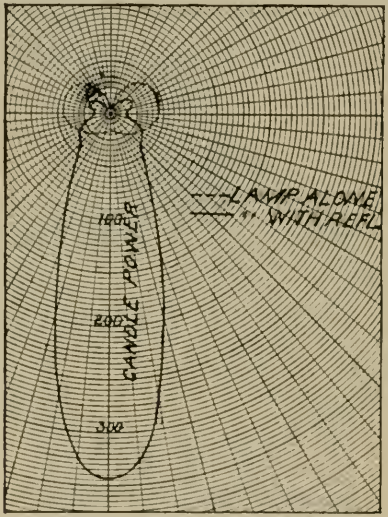
FIG. 4.



Photometric curve of opal reflector.

As a representation of the quantity of light emitted from a source, the photometric curve is exceedingly deceptive. The natural tendency in considering a curve of any kind is to regard the area as a representation of quantity. In Fig. 5 at first sight it would appear that the curve of the lamp and reflector shows a greater amount of light than the curve of the bare lamp. This is not true; the candlepower of the lamp and the total quantity of light are practically the same in both tests. The area of a photometric curve is meaningless. The reason is that the candlepower at the horizontal represents the intensity of light throughout a larger zone than the candlepower at the vertical. The zones throughout which the light is distributed might be compared to the zones on the surface of the earth. Consider for a moment a hollow transparent sphere with a light-source at the centre and zones similar to those on the earth laid out on the surface of the sphere. Take two zones of equal width, one near the equator and one near the poles. It is apparent at once that the zone near the equator is of greater area than that near the poles and since the photometric curve shows the candlepower in a vertical plane, candlepower values near the horizontal represent more light than equal values near the vertical. It follows that an average of candlepower values taken at equal intervals on the curve is not the average candlepower of the light-source. To obtain this true average or mean value, the curve can be plotted on what is known as the Rousseau diagram. This is illustrated in Fig. 6. The angles are laid off at distances proportional to the areas of corresponding zones on a sphere. The curve may be plotted on this diagram and readings then taken at equal intervals. The average of these readings represents the true average or mean candlepower in the upper or lower hemisphere or both as the case may be.

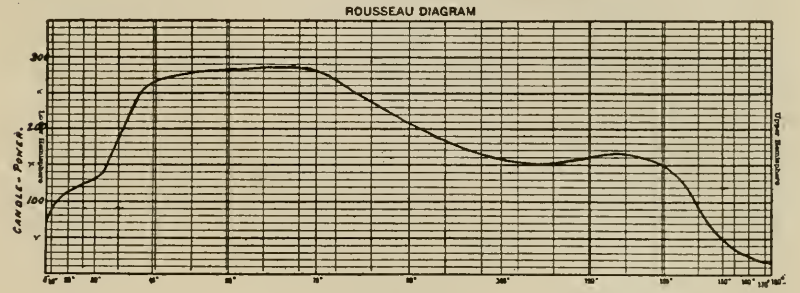
FIG. 5.



60 watt, 48 c. p. bowl-frosted Tungsten lamp with Holophane reflector, No. 9651.

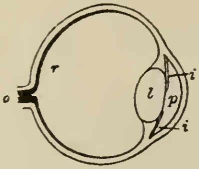
Recently a shorter method of determining this has been introduced and is represented in Fig. 8. In each hemisphere ten lines are shown, and if candlepower readings are taken from the photometric curve at each of these ten angles, and their sum divided by ten (in other words, the average taken) the result will be the mean lower hemispherical candlepower or the mean upper hemispherical candlepower as the case may be. These lines are so spaced on the diagram that they represent mean candlepowers of zones of equal area on the surface of a sphere. The angles may be laid off on a piece of transparent celluloid which can then be placed on any curve and the readings taken. An advantage of this method is that it enables one to obtain mean values in other zones by properly laying off the angles. For example the mean candlepower in the zone from 0 to 60 degrees can be obtained by means of a piece of celluloid with ten lines properly spaced for taking ten readings in this zone. The advantage of the ten readings is that in taking the average of the readings, ten is the easiest number to divide by.

FIG. 6.



Curve of D. C. 5¼ amp. arc lamp, with opal inner and clear outer globes.

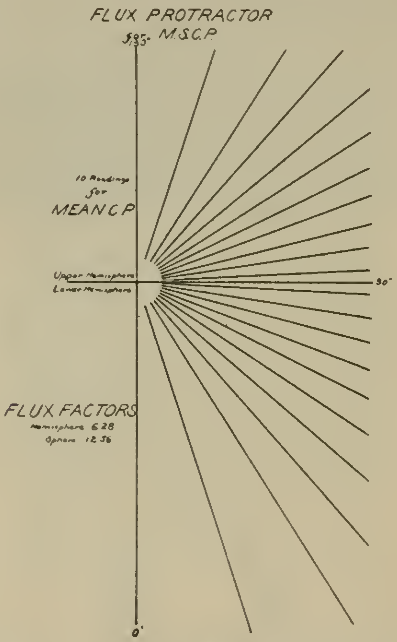
FIG. 7.



Section of the eye

In order to give some idea of the reason why the science of illuminating engineering has grown so rapidly it is necessary to realize what immense improvement can be obtained by properly calculating the lighting system of a room. The photometric curve of a bare lamp shows that practically the same amount of light passes above the horizontal as below. The light which passes above the horizontal is useful only in illuminating the ceiling and for illuminating the lower part of the room by being reflected downward. The quantity of this light which is reflected under ordinary conditions is shown by the reflecting power of various colors. For instance, according to Bell,[1] ordinary white foolscap paper reflects about 70 per cent. of the light striking it; orange paper reflects about 50 per cent.; yellow paper reflects 40 per cent.; pink paper 36 per cent.; light blue 25 per cent.; emerald green 18 per cent.; bluish green 12 per cent.; ultramarine blue only about 4 per cent. In addition to this, when it is considered that the light rays which pass upward are ordinarily reflected two or three times before reaching the lower part of the room, causing

FIG. 8.



Protractor for obtaining mean candle power readings.

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[1] Standard Handbook for Electrical Engineers (McGraw Pub. Co.), p. 745.

this coefficient of reflection to enter as the second or third power, it becomes evident that the light which passes upward is very largely wasted. Recent tests[2] on the effect of light and dark walls, ceiling and floor show that under conditions by no means extreme either way, a difference of about 4½ to 1 can be obtained in the illumination resulting from the same lamp. In addition, when the efficiency of incandescent lamps is considered, we have the choice between carbon filament lamps in ordinary use, consuming 3.5 watts per candle, and tungsten lamps, recently introduced, which consume 1¼ watts per candle. We can, therefore, obtain a difference of 13 to 1 in the cost of securing illumination by simply varying conditions which might appear trivial to one who is not familiar with the problem. This is a remarkable state of affairs, and is without a parallel in other branches of engineering.

Up to about ten years ago practically no attempt was made in designing a lighting system, to obtain uniform illumination of any desired intensity. In electric lighting certain rules as to watts per square foot or watts per cubic foot were applied indiscriminately, paying little attention to the color of the walls, to the character of the room, the position of the lights or the absorption and distribution of light by the globes and reflectors used. After the wattage had been determined the lights were spaced largely by guess-work or with the idea of obtaining the best appearance with regard to the details which the architect wished to bring out. The first method of calculating illumination was called the point-by-point method, and consisted in assuming a certain lighting system, then finding the illumination at typical points in the room by means of the formula stated in the first part of this paper. Then if the lighting system was not good as shown by these calculations, it was changed and the calculations repeated. This was a rather laborious procedure, but the few men who used such calculations soon became experienced enough to design a lighting system with little actual figuring, and they used the point-by-point method largely for checking.

Recently, however, a much shorter method of calculation called the flux method has been introduced. Its development is largely due to the work of Messrs. Cravath and Lansingh.[3] By this method the flux or quantity of light emitted from the light-source in useful directions is used as a basis rather than the candlepower or light intensity in any direction. With small light-sources the lumen or unit of quantity of light is the flux of light emitted in unit solid angle by a light having an intensity of one candlepower in all directions. It so happens that this quantity of light divided by the area of the surface which it strikes gives the average foot-candle intensity of illumination on this surface. This can be briefly shown as follows. Consider a sphere of radius r with a light-source of average candlepower P.

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[2] "Some Experiments on Reflection from Ceiling, Walls, and Floor"—V. R. Lansingh and T. W. Rolph, in the Transactions of the Illuminating Engineering Society, vol. iii, p. 584, Oct., 1908.

From the law of inverse squares—

Average foot-candles on the surface of the sphere $= \frac{P}{r^2}$. The area, A, of the sphere is $4\pi r^2$; hence $r^2 = \frac{A}{4\pi}$.

There are 4π unit solid angles in any sphere; hence the lumens generated $= 4\pi P$.

$$P = \frac{\text{Lumens generated}}{4\pi}$$

$$\therefore \text{ average foot-candles} = \frac{\text{lumens generated} \times 4\pi}{4\pi \times A}$$

$$= \frac{\text{Lumens}}{\text{Area}}$$

This applies for a plane or any other surface as well as a sphere, so that the average foot-candle intensity on any surface may be found by dividing the flux striking that surface by the area of the surface. This is a very convenient fact and enables us to obtain the average foot-candle intensity in a room by simply knowing the total number of effective lumens and the area of the room. By effective lumens is meant the total quantity of light striking the plane of illumination or, in other words, the total light generated minus that absorbed by the ceiling, walls, floor, and lighting accessories. The total number of effective lumens must be based upon some estimate as to what proportion of the light is effective, but we can work within a small limit of error when we know the photometric curve of the light unit and the conditions of the ceiling and walls. For example, with light ceiling and dark walls and prismatic intensive reflectors we know that the effective light is the equivalent of the light emitted from the light unit, up to about 75 degrees from the vertical. We can find from the photometric curve by the method previously explained the number of lumens produced by the light-source in this zone. The total lumens necessary is the product of the intensity of illumination desired and the area of the room. Knowing the lumens necessary and the effective lumens from each light-source, it is an easy matter to determine the number of light-sources required. These light-sources must then be placed in such a way that the illumination will be uniform, but this placement is not difficult for one who is familiar with photometric curves.

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[3] "The Calculation of Illumination by the Flux of Light Method"—J. R. Cravath and V. R. Lansingh, Transactions of the Illuminating Engineering Society, vol. iii, p. 518, October, 1908.

A short way of applying this method of calculation consists in using certain constants, which have been determined by illumination tests. These constants show the lumens per watt or foot-candles per watt per square foot obtained under various conditions, such as different colors of the walls and ceilings, different kinds of reflectors and globes, and different kinds of lamps.

The formula for using these constants is as follows:

$$\text{Total watts necessary} = \frac{\text{foot-candles desired} \times \text{area of room}}{\text{lumens per watt}}$$

The constants given below apply for a medium-sized or large room with light ceiling and lamps 8 to 15 feet above the plane of illumination.

Lamps	Equipment	Walls	Constant lumen per watt
Tungsten at 1.25 w.p.c.	Clear prismatic reflectors..........	Light	5.0
Tungsten at 1.25 w.p.c.	Clear prismatic reflectors..........	Dark	4.0
Tungsten at 1.25 w.p.c.	Enam. or etched prismatic reflectors	Light	4.3
Tungsten at 1.25 w.p.c.	Enam. or etched prismatic reflectors	Dark	3.4
Gem at 2.5 w.p.c.	Clear prismatic reflectors..........	Light	2.2
Gem at 2.5 w.p.c.	Clear prismatic reflectors..........	Dark	1.8
Carbon at 3.1 w.p.c.	Clear prismatic reflectors..........	Light	1.8
Carbon at 3.1 w.p.c.	Clear prismatic reflectors..........	Dark	1.5
Carbon at 3.1 w.p.c.	Lamps bare	Light	.60 to 1.3
Carbon at 3.1 w.p.c.	Lamps bare	Dark	.5 to .8
Carbon at 3.1 w.p.c.	Opal dome or cone reflectors	Light	1.7
Carbon at 3.1 w.p.c.	Opal dome or cone reflectors	Dark	1.4
5 amp. D.C. Arc	Clear inner and opal outer globes..	......	2.0

This method may be applied equally well for gas calculations in which case the formula would read:

$$\text{Cu. ft. of gas per h. necessary} = \frac{\text{foot-candles desired} \times \text{area of room}}{\text{constant}}$$

The constant would be lumens per cubic feet of gas per hour necessary to produce one foot-candle. Very few reliable illumination tests have been made on gas equipment, however, so that the method cannot be widely applied. Mr. Norman Macbeth[4] has determined the lumens per cubic foot of gas per hour for a large room with light ceiling, dark walls and inverted gas burners with prismatic reflectors. The value is 104. After the total watts or total cubic feet of gas per hour necessary have been determined they must be divided up among the number of units desired, spaced in the proper manner. This method of calculating illumination promises to prove exceedingly valuable. At the present time we lack constants for many conditions commonly met with. As fast as reliable illumination tests are made, however, constants can be added to the list and the scope of the table increased.

A paper of this kind is not complete without some consideration of various methods of equipping light-sources. Such equipment may be divided into three general classes; globes, reflectors, and shades. Globes are enclosing or partly enclosing accessories, which may or may not have a favorable effect upon the distribution of light obtained from the light-source. Reflectors are accessories which change the distribution of light by means of reflection. Shades, as their name implies, are accessories which have as an object the decreasing of the light intensity or the addition of some decorative effect desired. As a rule they do not have a favorable effect upon the distribution of light.

There are several kinds of enclosing globes in ordinary use. The principal ones of these are prismatic, opal, ground glass, and art glass. Neglecting the question of appearance, prismatic globes are superior to opal or ground glass, since their absorption is considerably less and they are designed to direct a large part of the light rays into a useful direction. Prismatic globes such as holophane, when designed and used correctly, absorb from 10 to 14 per cent. of the light. Tests on incorrectly designed prismatic globes have shown an absorption as high as 34 per cent. Opal absorbs from 25 to 60 per cent., depending upon the density. In order to obtain a desirable appearance opal globes should never be used unless they are sufficiently dense to hide the outline of the lamp filament. Ground glass absorbs from 20 to 40 per cent. Art glass has a very high absorption, but is valuable in obtaining decorative effects.

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[4] "The Illumination of an Auction Room"—Norman Macbeth, The Illuminating Engineer, November, 1908, p. 488.

There are a large variety of reflectors on the market, among which the most common are prismatic, opal, mirror, metallic, and coated. Reflection from any surface is of two kinds—regular or specular reflection and diffuse reflection. When a ray of light is regularly reflected the angle of incidence is equal to the angle of reflection. With diffuse reflection the light striking the surface is broken up into a large number of rays which leave the surface in all directions. Most surfaces give both regular and diffuse reflection with one kind predominant. Each kind of reflection has its advantage for certain cases. Certain types of distribution of light can be obtained only with surfaces giving specular reflection. On the other hand specular reflection with filament lamps often produces bright streaks or striations in the illumination of a surface. These can be eliminated by using frosted lamps and in some cases by using bowl-frosted lamps. Completely frosted lamps are usually undesirable because frosting reduces the life of the lamp about 50 per cent. Where the reflection is diffuse, striations are not usually met with.

With prismatic reflectors, it is impossible to direct all the light rays downward. This quality is not objectionable, however, for general illumination, since it is desirable to have a certain amount of the light pass upward in order that the ceiling and upper walls may not be in darkness. Prismatic reflection is specular reflection; it is, therefore, possible to direct a light ray in any direction and a prismatic reflector can be constructed to give practically any desired distribution of light. Mirror reflectors differ from prismatic reflectors in that they allow no light to pass upward. Reflection here is specular also, and, therefore, such reflectors can be designed to give nearly any desired distribution. The fact that they allow no light to pass upward makes them objectionable for general illumination, although a system of indirect illumination [5] recently introduced makes use of mirror reflectors. Opal reflectors are as a rule fairly efficient, but they differ from prismatic and mirror reflectors in that the reflection obtained is diffuse and not specular. This means that only photometric curves of a general rounded shape can be obtained. Opal reflectors having a depolished interior surface have recently been introduced. The depolished surface practically eliminates striations in the illumination obtained. These reflectors present an attractive appearance and have a good efficiency when used with clear lamps. Tests with bowl-frosted lamps are not yet available. Metal reflectors can be obtained in a large variety of styles and sizes. Their principal use is for factory lighting, although iron reflectors with a coating of white enamel are used considerably for street lighting. Reflectors for factory lighting are usually of aluminum, brass or steel. With such reflectors a diffuse reflection is highly desirable. This is usually obtained by a depolished aluminum surface or by aluminum paint.

Illuminating engineering covers so broad a field that this paper can do no more than touch a few of the essential features. Although the work of the illuminating engineer is comparatively new, it has proved so valuable that the development of the science and art has been exceedingly rapid. The literature on the subject has already assumed large proportions and each year sees additions of great value. The growth of the Illuminating Engineering Society is an evidence of the prevailing interest in the subject. Formed three years ago it has grown faster than any other engineering society in existence and now numbers over 1000 members. The papers presented before its meetings contain some of the most valuable data available on the subject. There is much work yet to be done before illuminating engineering is fully recognized as an important factor by all parties concerned, but at the present rate of advancement this complete recognition is not far off.

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[5] "Indirect Illumination"—Augustus D. Curtis and A. J. Morgan, Transactions of Illuminating Engineering Society, vol. iii, p. 740, Dec., 1908.

MINING & METALLURGICAL SECTION

(Stated Meeting held Thursday, April 1, 1909.)

ALLOY STEELS FOR MOTOR-CAR CONSTRUCTION.

BY

JOHN A. MATHEWS, Ph.D., Sc.D.

At the beginning of the twentieth century there was no automobile industry; to-day, before one decade has passed, we see a new industry of imposing magnitude. There are in the United States over two hundred and fifty makers of automobiles, and this number does not include makers of commercial motor vehicles and trucks. In short, it refers to makers of cars primarily for pleasure purposes. Upward of one hundred thousand employés are directly engaged in these factories and not less than four thousand allied industries and works are more or less dependent upon the motor-car industry. Truly this is remarkable growth and if, by reason of its years, this is still an "infant industry," all must admit that it looks like a thriving infant.

The value of sales of cars of domestic manufacture during the past six years is approximately two hundred and fifty millions of dollars, while over fifty millions have been spent upon foreign made cars.

As regards the productive cost of automobiles, both foreign and domestic, it appears that about 30 per cent. of the expense goes for wages and 60 per cent. for materials of construction. The remaining 10 per cent. represents salaries and materials for plants. Since 60 per cent. of the entire expense of manufacturing cars represents materials, no apology need be offered for presenting a paper before this Institute upon the *kind* of materials best suited for the construction of the vital parts. In this paper we propose to consider certain economic phases of the subject together with some matters of shop expediency and the relation of various manufacturing methods to the *quality* of the finished parts. We use the term "vital parts" advisedly because upon the quality of materials used in certain parts, the safety and even the life of the automobilist depends.

The exigencies of the demands of motor-car construction have proven a wonderful stimulus to the metallurgy of special steels. The heavy moral responsibility which rests upon both the maker and user of alloy steels and the tremendous duty expected of these materials of construction,—lightness without sacrifice of toughness or strength,—tend to make the requirements of the automobile trade most exacting.

While a few makers of automobiles and still fewer makers of steel accept this view and realize their grave responsibility, by far the majority of them seem lacking in this conception of their duty. With the steel maker it is too frequently a question of great tonnage only, and with the customer it is a question of buying at the lowest price, without due consideration of what the consequences of using cheap and inferior materials may be.

There are any number of steel makers who can display choice samples of their wares; the number of those who can furnish the same thing twice on order is much smaller. It is the ability to deliver the same article twice that makes for success in the manufacture of alloy or tool steel.

During the recent commercial depression the automobile industry thrived while the steel industry languished. A ruinous competition has been waged in the alloy steel business and these products have, in general, been sold at absurdly low prices, wholly inconsistent with that consideration of quality which motor-car construction deserves. This has retarded progress in the development of new steels.

It is inconceivable to my mind how any firm can conscientiously put out a car and not know intimately the materials used in every essential part. Yet such is frequently the case—gears are bought from " A " solely because his price is lower than that of " B " and " C," but the materials from which they are made are often unknown to the purchaser and rarely specified excepting perhaps in a general way. For example, nickel steel is asked for. Now nickel steel is a delightfully variable and uncertain quantity as ordinarily made. To say that you use nickel steel is about as definite as to say that you own an automobile—it may be a Packard limousine or a farmer's high-wheel auto-buggy. Both run by their own power on four wheels, but there the resemblance ceases. There are of nickel steels—like pickles—at least fifty-seven varieties, and the user should know what *kind* of nickel steel goes into his gears and who makes the steel as well as the gears.

Dr. Guillet, the distinguished French metallurgist, has previously pointed out that the constitution and mechanical properties of nickel steel depend essentially upon the sum C + Ni. From my own experience I should add to this sum + Mn. One hears continually in the trade nickel steel referred to solely by its percentage of nickel. Such expressions possess no real significance as a measure of quality or adaptability for various purposes. It is the skilful blending of the elements C + Ni + Mn that counts, and the successful accomplishment of this is a fine art. Almost as bad as not specifying at all is the tendency upon the part of many buyers to tell the maker how he ought to make his steel; to specify chemical analysis and physical tests which are a misfit, and, to quote Dr. C. B. Dudley, to make the wording of the specification " a place to show how much they know, as well as [to display] a mental attitude of favor or antagonism to any of the parties affected by it." I wish we might consider somewhat fully the subject of specifications, but for want of time I can only refer to Dr. Dudley's Presidential address to the American Society for Testing Materials, in July, 1903. It would be useless for me to attempt to add anything to what Dr. Dudley has so well said. Permit me, however, in passing to quote a few of his words:

" A specification for material should contain the fewest possible restrictions, consistent with obtaining the material desired. The service which the material is to perform, in connection with reasonably feasible possibilities in its manufacture, should determine the limitations of a specification. All parties whose interests are affected by a specification should have a voice in its preparation. Excessively severe limitations in a specification are suicidal. They lead to constant demands for concessions, which must be made if work is to be kept going, or to more or less successful efforts at evasion. Better a few moderate requirements rigidly enforced, than a mass of excessive limitations which are difficult of enforcement, and which lead to constant friction and sometimes to deception."

In these few words Dr. Dudley has spoken volumes and his entire address, " The Making of Specifications for Materials," will repay earnest study.

In my address this evening it is not my intention to weary you with long tables of analyses and physical tests. Perhaps a few will be mentioned incidentally and more added in an appendix. What I especially desire to emphasize are certain economic features in connection with the manufacture, purchase, use, and treatment of alloy steels of various types. Not all parts of an automobile demand especially high-grade material, while some parts demand the best of alloy steels. Indeed their use might well be made compulsory in the interest of public safety. We have seen manufacturers err in using too good materials in unessential parts, but the opposite tendency is more general.

Sound business judgment demands the best materials in vital parts, first, because of increased safety; second, because of the reduction in the guarantee cost, and third and most important, because of the advertising value of a clean score on breakage for a whole season's output. Dynamically strong axles, tough and strong steering parts, and springs which neither sag nor break are essential to comfort and safety. The crankshaft ought to be stiff and strong, the valve mechanism must resist wear, and the valve springs must retain their resilience indefinitely. Connecting rods, cap screws, clutch springs, gears and shafts, all moving and sliding parts of the transmission, bevel driving pinions and driving shafts, truss rods and torsion bars, all have more or less severe duty to perform and require materials possessing in various degrees resilience, strength, toughness, wearing qualities, and anti-fatigue qualities of high order. To make these parts of cheap and inferior stuff is not a good business proposition. The failure of such parts injures the reputation and name of any car and it is well to remember that contented owners of cars are their best advertisers.

As a manufacturer endeavoring to produce at all times the best qualities of tool and alloy steels, I see and hear much of that class of buyers to whom price is the all-important consideration. The ability, honesty, and reputation of the steel-maker carries no weight with them. A quarter of a cent difference in price far outweighs any considerations as to the relative knowledge, experience or facilities of competing makers. You can't get something for nothing and if you get something for next to nothing it is likely to cost you dear in the end. Let us consider what it means, for example, to buy a satisfactory steel for gears—

one which will produce gears that will never break—and a mediocre steel costing three-fourths as much from which some trouble is inevitable. A fair cost for a transmission, complete, would be perhaps eighty dollars; of this amount the steel for the gears themselves might cost ten or seven and one-half dollars, or one-half or three-eighths of one per cent. respectively of the $2000 car. By using the better steel you have increased the cost of your complete transmission a little more than three per cent. and the cost of the car by one-eighth of one per cent. This minute increase might readily represent the difference in cost involved and the results attained might well be considered very cheap advertising. Very few automobile makers are manufacturing on such a close margin of profit that they can afford to risk failure through false economy. The difference between a good and a poor steel of any particular class rarely exceeds two cents per pound. If the design is right and parts not needlessly heavy and if proper discrimination is shown in the selection of the right steels for various parts, the difference in raw material cost will amount to but a small percentage increase in the final cost and as an investment will be better than Standard Oil stock at par. The product is vastly improved; the car is safe and reliable; it advertises and sells itself.

I hope you will pardon me, if I digress for a few moments and tell you something of the steel company which I have the honor to serve as manager. We have good reason to take pride in our mill and equipment, and if any of you have ever visited our works I am sure you will confirm me in this. In general new steel mills are given considerable attention by the technical press and full descriptions are published with illustrations. Suffering from excessive modesty or other cause, very little has been given to the press about our plant. The Halcomb Steel Company is not even as old as the automobile industry. It is new in one sense only, however, it is a newly incorporated company with a new plant. Within five years it has erected the largest steel works in the United States devoted exclusively to the manufacture of high-grade tool and alloy steels. Competent authorities tell us we have the best arranged mill and equipment in the world for our class of work. That may seem a strong statement but I am quoting the opinions of English and American steel men and not my own. When the Lusitania made her maiden trip she was not manned with longshoremen. No, the best men in the employ of the Cunard Company were promoted; experienced men only were wanted. So in our plant, modern from stem to stern, we have an old mill organization of proven ability that has weathered many storms. Our working organization of department superintendents and foremen, intact almost to a man, has been associated for upward of twenty years in the manufacture of tool steel. Their fathers and grandfathers were steel men and their sons are following in the same occupation. Sheffield hasn't a monopoly upon ancestry in the tool-steel trade. We have men of the fifth and sixth consecutive generations of steelmakers with us and we cling tenaciously to the best methods and traditions of Sheffield tool-steel practice as regards the crucible process. We also have the first commercial electric steel-melting furnace erected on the Western Hemisphere. For three years the Heroult electric process has been used in our works. We thus combine conservatism and progress in our selection of methods of steel-making.

When we took up the manufacture of alloys for automobile construction we engaged as metallurgical engineer a man experienced in automobile engineering, a man familiar with specifications, testing and heat treatments, the design and construction of cars, and familiar with the troubles that have been encountered by the automobile manufacturers. In making these new alloys we want more knowledge of them than a chemical analysis and a tensile test. We consider the proposition in its entirety, including machining qualities and corresponding productive costs in the user's shop.

We manufacture many types of alloy steel but, of course, have our preferences. Upon request we can furnish expert advice in reference to the choice of materials for various parts and are pleased to co-operate fully with those desiring the best material in every part. By studying individual constructions, the expense of needlessly good material in unimportant parts is prevented while just the right thing for essential parts will be recommended.

No alloy steel is a universal steel. They must be selected with fine discrimination, giving due thought to the duties they must perform. Obviously the careful maker should be more intimately acquainted with his products than the user can be, both as regards chemical and physical qualities and thermal treatment and, hence, we willingly place our years of scientific and practical experience with alloys at the service of users of these products.

Quality rather than tonnage is our first desire. Each product must be the best of its kind; it must be uniform, year in and year out; it must be physically sound, free from pipes and seams and pass rigid inspection. In short our alloy steels are handled with all the care and minute attention to details affecting quality that characterizes our finest tool steels. This way of doing business costs money. When I mentioned a few moments ago paying a few cents a pound more for a good steel, that is just what I meant. I did not mean that one should pay ten cents for a seven cent steel. That won't improve the quality of the steel. I maintain that purchasing a steel *worth* ten cents is in nine cases out of ten economy over a steel *worth* seven cents, for use in vital parts.

Without attempting any scientific classification of alloy steels, or enumerating all types that have been used at home and abroad, I will briefly describe the principal types used in the American trade.

Nickel steel is perhaps the most generally used of the alloy steels. Its merits are often obscured by irresponsible makers whose product lacks uniformity—we have even heard of the nickel itself being omitted. The analysis usually desired but not always attained is, carbon .20–.25, nickel 3.50, manganese .60–.90, sulphur and phosphorus not over .04. With carbon and nickel as above stated manganese ought never to exceed the limits mentioned. A slightly lower carbon is sometimes used for case-hardening purposes, and a higher carbon is much used for crankshafts. With higher carbon we should prefer lower manganese. A small quantity of 5 per cent. nickel steel is used in about the same carbons. Certain firms claim to sell crucible nickel steels in these compositions; personally, I have never known of a pound of such steel being made commercially, and the prevailing price of nickel steel is pretty substantial evidence that it has not been produced by the crucible process. It is usually made in the basic open hearth furnace; with reasonable care, however, nickel steel can be made uniform, physically sound, and free cutting It has remarkably good mechanical qualities when subjected to suitable heat-treatment and is an excellent steel for case-hardening. In machining qualities it usually takes first place among the alloy steels. When extraordinary care is used in its manufacture, and it is not made in too large heats or ingots, and when piping and segregating is avoided by confining the finished product to that produced from the bottom two-thirds of the ingot, we have an admirable product for many purposes. In manufacturing such steel in the electric furnace, only relatively small ingots are made wherein segregation and piping are negligible.

Chrome vanadium steels in a profusion of types have of late attracted the profound attention of automobile engineers. Mr. J. Kent Smith has but recently discussed these products before this Institute, and his work in connection with these steels is deserving of the highest praise. As an illustration of the novelty of vanadium steel as a commercial commodity, I well recall being quoted $75.00 per pound for vanadium not many years ago.

The chrome-vanadium alloys are preferably made in the crucible or electric furnace, although the open-hearth process is also much used for the purpose. The open-hearth product, I believe, is somewhat uncertain and while, for example, an open-hearth chrome-vanadium spring-steel may be better than plain carbon crucible spring, it is not to be compared with genuine crucible chrome-vanadium steel when properly melted. For excellent quality, this product constitutes the highest attainment of the steel-maker's art.

These alloys are, in general, made in a high carbon type, suitable for oil-hardened gears and springs, and in several low carbon types,—such as a case-hardening type for gears and a type suitable for oil quenching followed by annealing for axles, shafts, and steering knuckles. By judicious blending of chromium and vanadium and adjustment of the manganese and carbon one can not only obtain all static properties that can be obtained from nickel, chrome-nickel, or silico-manganese alloys, but in addition obtain dynamic or antifatigue qualities far in excess of those displayed by any other alloys. A concrete example in confirmation of this will be given later.

From a wide experience with all types of alloys, it is my opinion that where a better material than the best nickel steel is needed, and especially when dynamic excellence is sought, the appropriate types of vanadium-chrome steels may be unreservedly commended. They forge well and machine more readily than chrome-nickels of corresponding carbon percentages.

Chrome-nickel steels are usually made in a high- and a low-carbon type. The former is used for oil-hardened gears and springs and the latter for general structural purposes, such as axles, shafts. forged parts and for case-hardened gears. The high-carbon type carries about one-half per cent. of carbon and the low-carbon alloy one-quarter of one per cent.; the nickel as supplied by various makers varies from two to three and a half per cent., while chromium from one to one and a half per cent. is usual. A nickel-chrome-tungsten steel is sometimes used for springs.

In general, nickel-chrome steels possess excellent static qualities but the difficulties in heat-treatment, forging, and machining lead one to prefer the other type of alloys previously mentioned. Equally good physical characteristics can be obtained more cheaply in first cost and in shop costs from nickel or chrome vanadium alloys. We shall speak further of the relative merits of these steels for oil-hardened gears and springs later.

Silico-manganese and silico-chrome in medium carbons have had considerable popularity abroad for springs and for gears. They, also, are made in low carbons. Their relatively low cost favors their use. but their feeble resistance to shock and sensitiveness to heat-treatment limits their use. When handled with great care they give good results in works well equipped for obtaining accurate results in their heating operations.

Chrome steels in high carbons are much used for balls and ball races.

Tungsten steels of special analysis are universally used for making magneto magnets. All statements and opinions to the contrary notwithstanding the magnet steel now made at two works in this country is rarely equalled in quality and never equalled in uniformity by foreign products. If foreign magnetos are superior to domestic ones it is because of their mechanical construction and not because they possess, in general, better magnets. The writer feels very deeply upon this subject and has probably made the most exhaustive experiments ever made upon the manufacture and properties of permanent magnet steel.

Having briefly described the type of alloys in general use we beg to submit some observations upon heat-treatments, upon the merits of case-hardened vs. oil-hardened gears; drop-forged gears vs. gears cut from the bar, and, in conclusion, a few words on springs.

Heat-treatment.—The best alloys are none too good for automobile construction; when one has secured the best the market affords, the first step only has been taken to produce good parts. Next come the forging and machining and the heat-treatment, for better or worse. It is money wasted to buy good alloys unless one is willing to study them sufficiently to know how to treat them and then to supply adequate facilities for so doing.

It is not to be expected that small users will install complete testing laboratories, but a few dollars invested in having occasional tests made will be well spent. There are, however, many large concerns that could and should spend, say $5000, for which it is believed the whole or a large part of the following equipment could be obtained: The ordinary tensile machine, a microscope, electrical or gas furnaces capable of fine regulation, a good pyrometer, preferably recording. The tensile machine can also be used for making Brinnell hardness tests, spring deflection tests, etc. In addition to these some form of drop-testing machine, such as the Fremont, will be found valuable; a vibratory or repetitive impact test is nowadays considered a necessity, while cold bending and torsion apparatus is useful. This equipment will be of small use, unless a thoroughly good man is put in charge—a careful, conscientious man of sound judgment. This man should direct the heating operations in the factory; he should construct furnaces which heat uniformly, and he should exercise eternal vigilance in keeping the pyrometer installations up to par.

The pyrometer is too often supposed to take care of itself. Too frequently it is never questioned, never calibrated. The best pyrometer of the thermocouple type should be looked over at stated intervals, especially if in constant use. Protecting tubes should be frequently examined and renewed, and electrical contacts looked over. Occasionally check up the millivoltmeter. Unfortunately there are many pyrometers of the thermocouple type on the market which cannot be watched too closely.

If you are going to have pyrometers, by all means see that you have good ones and then see that they are systematically tested. Many people buy high-priced alloy steels and get no better results from them than could be had from a carbon steel properly handled. If you cannot afford a good pyrometer stick to the trained eye of a skilled man; and if you have a good pyrometer employ a skilled man anyway, and consider the pyrometer as an aid. With it you can at least give orders in temperatures rather than in heat colors, and the laboratory and works can meet on an intelligent basis.

Heat-treatment operations depend upon a solid scientific basis. By this we do not mean that steel essentially of inferior quality should be made to pass muster by heat-treatment. On the other hand, however, it might be said that alloy steel in its so-called natural state, as it comes from the rolls, hammer or drop-forge, is almost unfit for automobile construction. Steel which depends upon alloys for a high elastic limit in its natural condition will have much less elongation than the same steel oil-tempered and annealed. For example, a chrome steel gave in its rolled condition 158,000 pounds elastic limit and 5 per cent. elongation, with 9.4 per cent. reduction of area. The same steel oil-tempered and annealed gave 153,000 pounds elastic limit, 14 per cent. elongation, and 52 per cent. reduction of area. In other words, the material was transformed from brittle to tough, from treacherous to safe, without materially affecting its elastic limit. A nickel steel similarly treated had its elastic limit raised 20 per cent. with the reduction of area improved and its elongation unchanged.

Case-hardened vs. Oil-hardened Gears.—In the automobile trade there have existed two schools, so to speak, one believing in the case-hardened type of gear and the other in the oil-hardened type. As previously mentioned the chrome-vanadium, chrome-nickel, and silico-manganese alloys are made in both high and low carbons. The former contain about .45 to .60 per cent. carbon and enough other hardening elements so that by merely quenching in oil from a bright red heat a surface-hardening is produced sufficient for ordinary wearing purposes while the hardness does not penetrate deeply into the gear but leaves a core that is tough and strong. The low carbon alloys, with about .20 per cent. carbon, require to be carbonized or case-hardened in order to produce sufficient surface-hardening for wearing purposes after hardening. The speaker's word on the merits of gears made by these two methods will hardly be accepted as final, as he is not an authority upon gears. Several years of observation and contact with the trade, however, leads me to prefer the case-hardened gear. The result of direct tests upon thousands of gears of both types leads me to the following conclusions: (1) The static strength of a case-hardened gear is equal to that of an oil-hardened gear, assuming in both cases that steel of the same class and appropriate analysis has been used and that the respective heat-treatments have been equally well and properly conducted. (2) Direct experiments proved that the case-hardened gear resists shock better than the oil-hardened. (3) As regards resistance to wear the same type is incomparably better, although perhaps not as silent in action.

One of the leading makers of gears has proved this to his own satisfaction of late by an arrangement of shafts and gears whereby energy is transmitted through two case-hardened gears, in mesh with each other, to two oil-hardened gears. The gears are of the same size. The conditions of the test were severe. Five sets of the oil-hardened gears have already been worn out while the original case-hardened gears are still in service and show the tool marks.

Upon the part of many there is strong objection to case-hardening. In nine cases out of ten this is doubtless due to the fact that the case-hardening operation has not been reduced to a science. The depth of case, the relation of case to core, the time and temperature to produce certain results and the exact control of these conditions, together with an accurate knowledge of the material to be treated, are the factors that enter into successful case-hardening practice. Further points in favor of this method are easier machining of the blanks, and at least equal static and dynamic properties with less chance of injury in hardening.

While considering gears, we may as well dip in a little deeper and consider the relative merits of gears cut from bars and from drop-forged blanks. Parts like spur gears, bevel pinions, and many shafts may either be drop-forged or cut from bars in automatic machines. Contrary to general opinion many parts can be machined out of bars as cheaply as they can be from forgings. Moreover, I am firmly of the opinion that no steel is improved physically by drop-forging, some steels, of course, being less susceptible to injury than others. In good steel mill practice great attention is paid to proper finishing heats, and steel is brought gradually to size. In drop-forging work, in order to give sufficient plasticity to assume various forms in dies, it must be heated very hot. It is then frequently formed with the fewest possible blows. An investigation of drop-forged and bar-cut gears, the former being the product of one of the foremost drop-forging companies, showed that under static test the bar-cut gears, as the average of many tests, were fully 25 per cent. stronger, and their resistance to shock test was also much better, but the difference cannot be exactly stated in percentage. The fact that the static test did not show more than 25 per cent. average superiority for the cut gear was a surprise to me and speaks well for the forging concern in question. In many cases, I fear a larger difference would be found. It is just such points in the construction of various makes of cars of the same general design that would be of great benefit to the would-be purchaser could he but know them.

To show that case-hardening is a science, let me quote from Dr. Guillet once more. In reference to the proper procedure in case-hardening he says: " As is well known, the operation of case-hardening consists of placing a steel in some medium capable of imparting carbon to it, at a suitable temperature; after a sufficient interval a steel is obtained the interior of which possesses the same percentage of carbon as before case-hardening, but the exterior of which is much higher (0.80 to 1.00 per cent.). On quenching such a steel an extremely high degree of mineralogical hardness is obtained on the surface, while the centre of the piece is non-brittle, if, that is, the operation as been properly carried out. One generally uses steels containing .10 to .25 per cent. of carbon for case-hardening. In order to avoid all brittleness in the interior and exterior of the piece, and, at the same time, to obtain a high degree of superficial hardness and a very regular degree of carburization (in carbon steels) it is necessary—

1. " To use a steel containing less than 0.12 per cent. of carbon, and with a low percentage of manganese (less than 0.30 per cent.) and—

2. " To case harden with a chemically definite material such as a mixture of 60 parts charcoal and 40 parts of barium carbonate at a temperature between 850° C. and 1050° C.—the higher the temperature the more rapid the case-hardening—and allow it, after the operation, to cool down just below the transformation point (about 600° C.).

3. " To reheat the piece and quench it at 900° C. (just above

the transformation point of the centre), this operation having the effect of rendering the centre fibrous."

This operation has the effect of toughening the centre but the outside will be coarse-grained and brittle. The next operation, according to Guillet is—

4. " To quench for a second time at 800° C. (above the transformation point of the exterior), to render the skin non-brittle.

" In any case, the methods by which it is possible to obtain, with low-carbon steel, case-hardened pieces which shall not be brittle, are exceedingly delicate."

How different this is from the operation one too often sees, where the pieces are dumped directly from the case-hardening boxes into water. However, if one uses a good grade of nickel steel, low in carbon, and case-hardens at appropriate temperatures, and then takes the precaution to cool off in the boxes before heating for quenching, and then hardens at about 800° C., the results will be fully equal or better than can be obtained by the most careful handling and double quenching of carbon steels. The saving in cost of the operation can be applied toward the greater cost of nickel as compared with ordinary case-hardening steel.

Better still, however, if nickel steel is used, is to give it a double quenching, too, then one obtains a really admirable product of extraordinary toughness and remarkable wearing qualities. An ideal way of making a nickel-steel gear consists in first annealing the blank, then rough-machining approximately to size, then giving a light reannealing before taking the last finishing cut. Then pack in suitable mixture and carbonize to a depth of $^1/_{64}$ to $^1/_{32}$ of an inch, according to requirements, at a temperature of about 1625° to 1650° F. Cool in the pots, heat to about 1500° F. and quench in a hot brine or calcium chloride solution. This will put the core into excellent physical condition. Finally, reheat to 1375° to 1400° F. and quench in oil. This last operation will refine the grain of the case and harden it with best results. The temper need not be drawn.

It will be noticed that the temperatures for treating nickel steels are considerably lower than those advocated by Guillet for carbon steels.

If methods like these are followed it is not likely that a very great difference would be noted between bar-cut gears and gears cut from drop-forged blanks. In the case of medium carbon gears not to be case-hardened but oil-hardened only, one would probably find a greater difference and in this case we have no opportunity to restore the over-heated forged blank by scientific heat-treatment. This, in addition to the greater chance of overheating and the greater difficulty of machining, also favors the use of case-hardened gears, assuming, of course, the case-hardening is to be skilfully done.

In conclusion, let me bring to your attention certain facts and considerations with reference to springs and spring making. There are in general two kinds of springs used in automobiles, coil and flat springs. The latter may be full, three-quarter, or half elliptic. From observation and general report it appears that the general maker of springs has not kept pace with the improvements in spring-steel and with the increased severity of the duty expected of springs. With many of them to suggest a change of method is like preaching heresy in a theological school.

The new steels cannot be handled just like the old ones and still obtain from them the maximum development of their powers. However, the new steels, being in general lower in carbon, will stand much abuse in heat-treatment and still produce springs of quality undreamed of a decade ago. But how foolish it is to pay four or five times the cost of regular spring-steel and then not adopt methods to develop its maximum excellence even to an increased endurance of a hundred fold over plain carbon spring steel!

While as a class spring-makers may have been driven to the use of alloy steels, they have not as a class been forced to handle them scientifically. I am happy to say there are a few exceptions to this and I hope their number will increase. The old practice of forming and hardening springs with a single heating cannot be persisted in if maximum quality and service is to be secured.

Satisfactory tests on flat springs are somewhat difficult to make but in coiled springs quality can be easily shown and the relative merit of different steels demonstrated. The most satisfactory test is to operate the springs,—open and close,—by some sort of repetitive impact method until destroyed. In order to produce results in a reasonable length of time the duty must be severe and the rate of alternations of stress rapid. The number of alternations of stress to produce fracture gives a measure of its vitality, so to speak. Average results of a great many tests made in this way of crucible carbon springs, chrome nickel, silico-manganese and genuine crucible chrome-vanadium springs proves the extraordinary quality of the last-named product and the antifatigue qualities imparted by vanadium. The average figures for alternations were as follows: crucible carbon spring, 125,000; chrome-nickel and silico-manganese, each 200,000; crucible chrome-vanadium, 5,000,000, and still unbroken. This, then, is the panacea for all valve, clutch, break, and flat spring troubles. The engineer of a company which makes a very heavy car and uses a semi-elliptic spring told me recently that they had not had a leaf to break or a spring to sag since adopting crucible chrome-vanadium springs made by an up-to-date spring-maker. Prior to this time they were in trouble all the time.

The tempering of this steel is quite simple. The springs should be heated to 1675° to 1700° F. and quenched in oil. The temper is then drawn according to the nature of the spring and the duty expected. The drawing range is very wide, namely, from 600° to nearly 1000° F. In the line of spring-steel this product has my profound admiration.

In what I have said this evening I have tried to impress upon you the importance of using high-class materials when severe duty is demanded, of using discrimination in the selection of special steels for special work, of looking beyond the first cost of your raw materials, and of studying the fascinating subject of heat-treatment. If I have succeeded in a measure in this, our evening will have been well spent. If I have caused any of you to think more deeply on these subjects or have made any one's conscience hurt him just a little bit because of past neglect, or have offered any practical suggestions which you can apply in your daily work to the betterment of your product, then I shall not regret having accepted the invitation to address you upon this important subject.

APPENDIX.

In presenting some tables showing typical analyses, treatments and tensile tests of nickel, nickel-vanadium, chrome-nickel, and chrome-vanadium steels, we have drawn upon many sources of information, as, for example, the data published by the American Vanadium Company, experimental data upon tests made by the writer, and commercial tests made upon the steels of many makers. The temperatures when given are approximately correct. In giving analyses only the essential elements have been given. We have expressed the elastic limits and tensile strength in net tons per square inch, and the elongations are as measured upon a two-inch test-specimen one-half inch in diameter.

These tables are given to illustrate the tremendous possibilities of careful heat-treatments, and in some instances they illustrate the danger of applying wrong treatments. The effect of variable carbon contents in alloys of the same type is illustrated, and varying qualities that may be obtained from the same alloy by different treatments may be observed.

One point I must mention in connection with these tests is, that in designing parts one must be very cautious not to be misled by the remarkable tests yielded when a standard test-piece is treated and to use these figures as a guide to the physical qualities likely to result when a much larger mass of metal is treated. Because a half-inch test-piece oil-tempered and annealed gives an elastic limit of 75 tons per square inch, it does not follow that an inch-and-a-half-diameter bar similarly treated will yield the same elastic. The hardening action in quenching does not penetrate very deeply in a large bar, while in a small one it may penetrate to the centre.

The writer once made a quantitative experiment upon this point, using a .43 carbon steel, containing vanadium. The steel was in the form of an inch-round rolled bar. In one case I oil-tempered a full inch section of the bar at 1600° F. and annealed it at 1030° F., and from this machined up a test-piece. In the other case, I made the test-piece from the inch-round bar, and having reduced it to a half-inch diameter test-piece, subjected it to the same treatment as I had applied to the full-sized bar. The piece treated in the form of a test-piece gave me 42.5 tons elastic limit, 58 tons tensile, 21.5 per cent. elongation, and 58 per cent. reduction. The other piece was over 4 tons lower in elastic limit; over 3 tons lower in tensile, and 2.2 per cent. and 3.6 per cent. higher in elongation and reduction respectively. This shows that while it may be quite possible to obtain an elastic limit of 100 tons in a thin spring, one would not have the same elastic by the same treatment had the same steel been made into a massive gear.

Many of the figures given in the tables are the averages of several tests made upon materials of the same general kind, and in the first column of the tables is given the number of tests, either average or single, upon which the figures are based.

In the column marked " treatment " is given the temperature to which the steel has been heated, followed by the liquid in which it was quenched, and then by the temperature to which it was reheated to draw the temper or anneal. This will make clear such terms as 1600° F.—oil—600° F., etc.

TABLE 1.—NICKEL STEELS.

No. of Tests.	C.	Mn.	Ni	Cr.	V.	E. L.	T. S.	Elong. in 2″.	Red. in A.	Treatment.
4	.21	.86	3.48	...	...	68	112	13.7	45	1550 F. oil 600 F.
4	.25	..	3.50	...	...	85	109	13.4	..	1550 F. oil 600 F.
2	.27	..	3.50	...	...	86	110	13.3	51	1550 F. oil 600 F.
30	.18-.28	.60-.90	3.5	...	...	68	103	12.9	54	1550 F. oil 600 F.
11	.18-.28	.60-.90	3.5	...	...	84	116	12.4	48	1600 F. brine.
4	.25	.60-.90	3.5	...	...	88	121	12.2	48	1600 F. brine.
7	.23	.61	3.54	...	...	103	114	14.0	50.7	1550 F. water 212 F.
1	.14	.63	3.64	...	...	78	88	15.0	54.6	1500 F. water 212 F.
1	.14	.63	3.64	...	...	30	41	33.5	72.4	1400 F. oil 1200 F.
4	.35	.45	3.39	...	...	77	84	15.5	55.5	1500 F. water 900 F.
4	.35	.45	3.39	...	...	130	137	10.0	36.3	1500 F. water 430 F.
3	.25	.86	3.45	...	...	31	45	31	60	Natural, as rolled.

TABLE 2.—NICKEL-VANADIUM STEELS.

No. of Tests.	C.	Mn.	Ni.	Cr.	V.	E. L.	T. S.	Elong. in 2″.	Red. in A.	Treatment.
1	.34	.17	3.88	...	..	29	43	27.3	54	Natural as rolled.
1	.33	.16	3.72	...	.12	41	54	23.8	53	Natural as rolled.
1	.33	.16	3.40	...	.24	49	66	17.8	40	Natural as rolled.
1	.34	.17	3.88	...	..	37	51	16.5	51	1500 F. oil 1150 F.
1	.33	.16	3.72	...	.12	51	59	24.0	61	1500 F. oil 1150 F.
1	.33	.16	3.40	...	.24	59	62	21.0	61	1500 F. oil 1150 F.
1	.34	.17	3.88	...	..	59	66	15.5	55	1500 F. oil 600 F.
1	.33	.16	3.72	...	.12	70	76	14.5	56	1500 F. oil 600 F.
1	.33	.16	3.40	...	.24	82	85	15.0	55	1500 F. oil 600 F.
1	.24	.72	3.33	...	.12	38	49	27.0	64	Natural as rolled.
1	.24	.72	3.33	...	.12	71	100	11.6	36	1600 F. oil.
1	.24	.72	3.33	...	.12	92	117	14.5	52	1600 F. water.
1	.24	.72	3.33	...	.12	91	116	15.2	57	1600 F. brine 400 F.

TABLE 3.—CHROME-VANADIUM STEELS.

No. of Tests.	C.	Mn.	Ni.	Cr.	V.	E. L.	T. S.	Elong. in 2″.	Red. in A.	Treatment.
3	.26	.39	...	.78	.17	44	68	20	64	Natural as rolled.
1	.26	.39	...	.78	.17	103	139	3	8.2	1570 F. oil 400 F.
3	.27	.50	...	1.00	.17	33	45	28	62	Annealed 1475 F.
1	.27	.50	...	1.00	.17	52	63	21	56	Oil tempered and drawn to various degrees.
1	.27	.50	...	1.00	.17	62	65	17	62	
1	.27	.50	...	1.00	.17	70	74	17	57	
1	.27	.50	...	1.00	.17	100	106	12	51	
1	.27	.50	...	1.00	.17	112	116	11	39	
1	.40	.77	...	1.22	.19	34	50	26	62	Annealed.
1	.40	.77	...	1.22	.19	98	104	10	36	1650 F. oil 840 F.
1	.30	.50	...	1.00	.16	71	76	16	56	1650 F. oil 1025 F.
3	.38	.73	...	1.19	.18	41	65	22	67	Natural as rolled.
1	.38	.73	...	1.19	.18	110	144	10.8	47	1660 F. oil 600 F.
1	.38	.73	...	1.19	.18	64	113	12.9	53	1660 F. oil 850 F.
1	.33	.54	...	1.24	.20	64	71	15.5	56	1500 F. oil 1125 F.
1	.33	.54	...	1.24	.20	95	104	11.0	38	1600 F. water 600 F.
5	.45	.58	...	2.37	.30	88	94	13.2	46	1600 F. oil 1125 F.
4	.45	.58	...	2.37	.30	138	146	6.0	16	1600 F. oil 430 F.
1	.36	.21	...	2.78	.24	60	104	4.1	88	Natural as rolled.
1	.36	.21	...	2.78	.24	65	72	20	56	1500 F. oil 1150 F.
1	.36	.21	...	2.78	.24	98	104	13	45	1500 F. oil 600 F.

TABLE 4.—CHROME-NICKEL STEELS.

No. of Tests.	C.	Mn.	Ni.	Cr.	V.	E. L.	T. S.	Elong. in 2″.	Red. in A.	Treatment.
1	.37	. .	2.9	1.04	...	60	78	18.5	61	1475 F. oil 1200 F.
4	.37	. .	2.9	1.04	...	77	84	16.	56	1500 F. water 1100 F.
1	.45	. .	2.0	1.0	...	70	90	8.0	20	Oil-temp. and annld.
1	.25	. .	2.0	1.0	...	50	65	12.0	30	Oil-temp. and annld.
2	.25	. .	3.0	1.5	...	57	64	15.0	65	Annealed.
1	.25	. .	3.0	1.5	...	110	116	6.0	40	Hardened—oil.
1	.50	. .	2.0	1.0	...	33	46	27.0	64	Natural as rolled.
3	.50	. .	2.0	1.0	...	72	134	6.0	23	Tempered.
1	.30	. .	2.0	1.0	...	35	53	18.0	45	Natural as rolled.
1	.30	. .	2.0	1.0	...	68	98	9.0	37	Tempered.
1	.30	. .	2.0	1.0	...	45	55	25.0	55	Oil-temp. and annld.
1	.40	.18	2.1	.80	...	60	76	12.8	37	Natural as rolled.
1	.40	.18	2.1	.80	...	58	66	17.5	40	1500 F. oil 1150 F.
1	.40	.18	2.1	.80	...	106	118	10.0	34	1500 F. oil 600 F.
1	.40	.18	2.1	.80	...	70	79	15.5	48	Annealed 1150 F.

ANNUAL REPORT OF THE SCHOOLS FOR THE SESSIONS OF 1908–1909

THE DRAWING SCHOOL.—The Drawing School has done excellent work this year notwithstanding the reduced attendance, due to the prevalent industrial depression. The development of the understanding and the capabilities of very many of the students has been striking, and all have been benefitted more than they are aware of. They have acquired a good conception of what graphic illustration, construction, demonstration and proof can do, and are much better prepared to take up the theoretical and academic part of engineering, structural work, architecture or original designing of any kind, than if they had begun the other way and treated the graphics as a mere adjunct. They have also slowly absorbed the idea that it is just about as easy and as quick to do things well and in good style as to do them poorly and in a slovenly manner, and that the final results of the former are far superior.

Those graduates who have selected this line of industry as their life-work, or who are so situated as to make it desirable to do so, and who believe themselves fairly capable on the graphic side, should immediately follow it up with the mathematical part, and those who do not so believe should continue at the drawing, notwithstanding their graduation, until they do.

On the part of the Institute greater effort should be made to exploit the schools. They are unique, in that the instructors are experts in their lines, and that the instruction is individual and personal and not perfunctory. The instructors may not be graduates in pedagogy, but they are skilled in what they teach, and coming into such close contact with the students, the latter absorb their methods and experience in a way that no class instruction can produce. This should be made more generally known, and the public be continually informed of the superior opportunities afforded by this Institute, with all its inadequate material facilities and its unattractive appearance and location.

WILLIAM H. THORNE, *Director.*

THE FOLLOWING STUDENTS HAVE DESERVED HONORABLE MENTION:

In the Senior Mechanical Class,

Walter Dardenne,
Robert J. Heisserman,
Walter T. Sulger,
James B. Stites,
William H. Weldon.

In the Intermediate Mechanical Class,

Ernest Baumer,
George Griesel,
George Goldsmith,
Joseph Leinmiller,
Alonzo C. Devlin.

In the Junior Mechanical Class,

William Meinel,
Thomas Moore,
Joseph Ulrich Boss,
Gustav Heinecke,
James Flynn.

In the Architectural Class,

Stacy Dear,
Howard G. Tomlinson,
Joseph C. Swartz,
William Burke,
Richard D. Tifft,
Stanley K. Weber,
Charles Nelson Rocholl,
Ara S. Pennewell.

The Following Students are Awarded Scholarships from the B. H. Bartol Fund, entitling them to tickets for the Next Term.

Walter Dardenne,
Ernest Baumer,
Stacy Dear,
Howard G. Tomlinson,
William Meinel.

The Following Students having Attended a Full Course of Four Terms, with satisfactory results, are Awarded Certificates.

Robert J. Heisserman,
William H. Weldon,
Walter T. Sulger,
James B. Stites,
Ephraim Foster,
Clarence A. Fish,
Charles R. Yerger,
Frank H. Sauer,
John Joseph McCormick,
John A. Schneider,
David H. Trego,
Olei Johnson,
Charles A. Frey,
James Campbell,
Edward Allen,
Elmer E. Snyder,
Charles Herbert Ireland,
Michael Herbert,
William Burke,
Stacy Dear,
Richard D. Tifft,
Joseph F. Harris,
Edward Frehafer.

The School of Machine Design.—During the past session the policy adopted at the time of the school's organization has been continued of covering a relatively narrow field in construction engineering and requiring that this be carried on in a thorough manner.

This policy does not encourage any but those who are sincere in their desire to master the subjects offered and willing to devote the greater part of their leisure to that effort.

There is a mistaken impression among many who are about to undertake study of this kind that satisfactory results may be expected by devoting to it only the time scheduled for class hours and in consequence the preparatory classes suffer considerable losses by the resignation of men who cannot, through lack of application, keep pace with the prescribed development of the subject. In addition to covering, in detail, the ground specified a constant effort is made to lead the student to the habit of independent thought, and to that end he is encouraged never to accept the conclusions of a text without satisfactory proof. Indeed, at no stage of the course is the student offered a result without demonstration. The aim has been briefly, to make the course a deductive one and to eliminate features that savor of "cook-book" system of engineering instruction.

As may be expected there are no text-books fully adapted to meet the needs of such a course due to the limited field of the mathematics employed. To meet this deficiency the instruction staff has prepared hektograph notes, supplementing the texts adopted, for distribution in the classes. There is now a considerable accumulation of these notes and if the opportunity is found they will be incorporated in future text-books compiled to meet the particular needs of the course.

The poor furnishings of the school are, of course, unattractive and have often been commented upon, but it may be pointed out that the efficiency of a school is not measured by elaborate equipment, but by diligence and capacity of the student body and teaching staff.

The Director welcomes this opportunity of acknowledging his indebtedness for their painstaking and efficient co-operation to Mr. C. F. Chambers, who conducts the class in algebra, and Mr. Arthur C. Heintze, who directs the class in geometry and trigonometry. LUCIEN E. PICOLET, *Director.*

THE FOLLOWING HAVING SATISFACTORILY COMPLETED THE REQUIREMENTS OF THE COURSE ARE ACCORDINGLY AWARDED CERTIFICATES:

A. J. Beuter,	C. F. Krauss,	A. H. Petri.
E. C. Gardiner,	W. L. Lukens,	

THE SCHOOL OF NAVAL ARCHITECTURE.—The small attendance at the Night School of Naval Architecture is very largely attributable to the fact that the average draftsman employed in the shipbuilding yards of this country does not realize the importance, or even the desirability of becoming acquainted with the scientific features of shipbuilding. The idea is prevalent that theory is in most cases diametrically opposed to practice, and that therefore a practical experience is far more valuable than a theoretical education. The fact is lost sight of that theory is never at variance with practice, but on the contrary, that theory is entirely the result of practical experience carefully observed and analyzed. The pernicious result of this idea is that the majority of ships draftsmen never become possessed of more than mediocre ability and never become competent to fill positions requiring more than a moderate amount of technical skill. If the great benefit of a scientific training, not only in its direct and immediate application but also because it develops the ability to properly devise economical and efficient solutions of ordinary practical problems, could only be properly appreciated, the number of students would undoubtedly be greatly increased. Other circumstances also operate against a large attendance, such as inadequate facilities for efficient teaching, which is in all probability only temporary, expensive text books, and the short time allotted to the work. These unfavorable circumstances are of a serious character, but they could be in a measure overcome, if a sufficient interest could be aroused among the men from whom the recruits for this course must be largely drawn.

The same difficulties in regard to the inadequate preliminary preparations under which a great many of the students have labored, have been experienced this year as in the past. The utter impossibility of undertaking this course without at least an elementary mathematical training has been responsible for the decreased attendance during the second term. But on the other hand, the earnest endeavor and faithful attendance of those students able to continue has been of material benefit to them and has greatly encouraged the efforts of the instructor. On account of the limited time at our disposal and also because the greatest need seemed to lie in that direction, the attention of the class has been mainly directed toward theoretical naval architecture. M. H. KEIL, *Director.*

The following students have successfully completed the required course of two years and are therefore entitled to certificates of graduation: Joseph McDermott, Wm. Serad, Jr., Chas. Vanstone.

FRANKLIN INSTITUTE

(*Proceedings of the stated meeting held Wednesday, April 21, 1909.*)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 21, 1909.

President WALTON CLARK in the Chair.

Present, forty members and visitors.

Additions to membership since last report, four.

A communication was presented from Mr. Henry Howson, surviving trustee of the Elliott Cresson Medal Fund, announcing the death of his co-trustee, Dr. William H. Wahl, and requesting that another trustee be elected to fill the vacancy. In accordance with the deed of trust the matter will lie over until the next meeting.

The Chairman announced the death of Dr. Persifor Frazer and called attention to the vacancy on the Board of Managers. On motion, duly seconded, Mr. James S. Rogers was nominated to fill the vacancy, and as there were no other nominations he was unanimously elected.

The paper of the evening was then presented by Mr. Charles E. Rice, M.E., on the "Evolution in Design, Manufacture, and Uses of Typewriting Machines." The speaker reviewed the history of the typewriting machine, beginning with the invention of Thomas Hall in 1880 up to the present time, giving special attention to the construction and manufacture of the Underwood Typewriter.

Mr. Charles V. Oden then gave a demonstration of the practicability of the Underwood Typewriter; he was assisted by Miss Rose L. Fritz who recorded the speaker's introductory remarks, 570 words in five minutes and twenty-four seconds. Miss Florence E. Wilson demonstrated the speed of the Underwood Typewriter by copying one hundred and sixteen words of reading matter in one minute. Mr. H. O. Blaisdell recorded two hundred and twenty words of unfamiliar matter from a newspaper in two minutes. Mr. E. Trefzger took dictation at the rate of 227 words in two minutes.

On motion a vote of thanks was tendered the speakers and the demonstrators for their interesting papers and exhibition. Mr. Rice's paper was referred for publication, and the subject of the Underwood Typewriter was referred to the Committee on Science and the Arts for examination and report.

JAMES CHRISTIE,
Secretary.

COMMITTE ON SCIENCE AND THE ARTS

(*Abstract of proceedings of the stated meeting held Wednesday, April 7, 1909.*)

MR. J. Y. MCCONNELL in the chair.

The following report was adopted:

(No. 2446.) *Milling Files.*—Alexis Vernaz, Yverdon, Switzerland. Reserved for publication in full. The Elliott Cresson Medal is awarded to the inventor. [Subcommittee.—William H. Thorne, Lucien E. Picolet, George S. Cullen.]

The following protest was disposed of:

(No. 2400.) *Primary Battery.*—Frank A. Decker, Philadelphia.
(An advisory report.)

The following report passed first reading:

(No. 2449.) *Emergency Exit Door Lock.*—Hugh Elmer Clark, Rochester, N. Y.

R.

BOOK NOTICES

ALTERNATING CURRENT MACHINES. Being the second volume of "Dynamo Electric Machinery, its Construction, Design, and Operation." By Samuel Sheldon, A.M., Ph.D., D.Sc., Professor of Physics and Electrical Engineering at the Polytechnic Institute of Brooklyn and Past-President of the American Institute of Electrical Engineers; and Hobart Mason, B.S., E.E., Associate of the American Institute of Electrical Engineers; and Erich Haasmann, B.S., E.E., Instructor in Electrical Engineering at the Polytechnic Institute, Brooklyn, and Associate of the American Institute of Electrical Engineers. Seventh edition; completely rewritten; xi + 353 pages, 5¼ x 7½ inches. D. Van Nostrand, New York; Crosby, Lockwood, London. Price, $2.50 net.

The appearance of the seventh edition of this book bears testimony to its value in the field covered. The subject has been treated rather with view to meeting the needs of students who are endeavoring to master the subject by their own efforts than of engineers who presumably already know the subject and whose requirements are met by a less detailed account.

The mathematics employed cover the range of subjects usually presented in an undergraduate engineering course and the book's greatest field of usefulness undoubtedly lies in its inclusion in such a course rather than among students of the self-instruction class.

The value of numerical computation has been duly borne in mind by the inclusion of a large number of examples at the end of each chapter.

L. E. P.

POLARISATION ET SACCHARIMETRIE. Par D. Sidersky, Ingenieur-chimiste. 168 pages 4½ x 7½ inches; with 40 illustrations. (Encyclopedie scientifique des Aide-Memoire.) Price, paper, 2 francs 50; cloth, 3 francs. Gauthier-Villars, Paris, 1908.

The study of rotary polarization and its numerous practical applications to analytical chemistry is thoroughly set forth in this small volume and the various forms of instruments used are illustrated and described in detail.

The new edition is brought up to date by the inclusion of the latest researches on the subject, and the volume should prove of the greatest value to the analyst utilizing this method.

L. E. P.

LABORATORY EXPERIMENTS IN METALLURGY. By Albert Sauveur, Professor of Metallurgy and Metallography in Harvard University, and H. M. Boylston, Instructor in Mining and Metallurgy in Harvard University. Seventy-three pages, illustrations, plates, tables, 8vo. Cambridge, Mass., The Authors, 1908. Cloth. Price, $1.25.

This book gives an outline of a course in metallurgy which will be useful to those in charge of college work upon this subject. A general idea is given of the properties of some of the more common metals. Several pyrometers are described and one calorimeter. It is rather curious, however, that no mention is made of the bomb calorimeter, which is everywhere recognized as the standard of accuracy.

One-half of the experiments relate to the metallurgy of iron and steel, and most of them deal with the important subject of "heat treatment."

R. J.

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ELECTRICAL SECTION

(Stated meeting held Thursday, April 15, 1909.)

TRANSMISSION OF INTELLIGENCE ON STEAM VESSELS.

BY

H. A. HORNOR,

Electrical Engineer, New York Shipbuilding Co.

COMMUNICATION on steam vessels divides itself into signals for navigational protection from other craft and means whereby it may securely provide for its own safe carriage of human life and cargo; on the one hand exterior communication to ward off collision, as well as maintain its own legal course, on the other interior communication for the proper, lawful and safe manipulation of the vessel and the accommodation of her passengers, officers, and crew. Exterior communications required by law are: Running and anchor lights, searchlights (in some instances), steam whistle, siren fog whistle, rockets, etc. Wireless telegraphy, submarine signals, night signal sets, electric flash lights for steam whistle, are carried on many vessels to-day as a greater factor of safety. The scope of this paper will not permit even a brief description of these systems, if indeed a brief descrip-

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[NOTE.—The Franklin Institute is not responsible for the statements and opinions advanced by contributors to the Journal.]

tion could be made, and attention will be addressed solely to the reasons for, and the present means of, interior communication on steam vessels.

It is generally known that steam vessels vary greatly in type. Therefore a standard steamship is but the immaterial mind-wanderings of the hopeful shipbuilder—he who would like to manufacture ships as they do screws, or pens. But it does not occur to many that other than the varying types the vessel usually is for some particular or special service. Thus one might fancy that a number of ships designed exactly alike in regard to form, line, propulsion, etc., and yet for a different service, must, to satisfy this service, be very differently equipped. So passenger and freight vessels for our coastwise shipping, though resembling transatlantic Leviathans, employ docking telegraphs because they can more economically and time-sparingly enter their docks. The transatlantic and transpacific vessels, due to their size or due to the docking facilities, depend upon tug-boats for these manœuvres. Ferry-boats which are constantly coming in or going out of their slips are provided especially with direction tell-tales which assure the pilot that the engines are rotating in such manner that the boat will advance when he has signaled for ahead motion. Avoidance of serious mishap is thus accomplished. River excursion steamers, whose superstructures are built entirely of wood, thereby requiring great vigilance for the detection of misanthropic fires, are supplied with a complete fire-alarm equipment, this system being so designed that hardly a square yard of the vessel is not guarded by such an appliance. For the assurance of the travelling public it may be well to note here that many of these vessels also carry a sprinkler system such as is now required in many of our land factories. Dredges which hold their working position by means of wooden poles (called spuds), which must be manipulated as their work progresses, require spud telegraphs which convey signals from the working platform to the men employed to raise or lower the spuds. So could be multiplied instances of differences in communication equipment for differences in service. Tempting as this subject is, the duty lies before us to describe the means of this communication and not its varying application.

Electricity holds an important place in the transmission of ships' signals, but this place is secondary as regards the movements of the vessels. Those signals which are necessary to navigation and manœuvring of the vessel are performed mechanically. The control of the main propelling engines from the bridge or pilot-house is accomplished by mechanical transmitters connected by bronze wire to receivers in the engine room. Wheels are encased in each instrument traversed by brass chains. To the ends of these chains the bronze wire is attached. Where corners are encountered triple linked brass chains are led over brass pulleys. In all cases reply signals are transmitted in order that no confusion may arise. The cycle is thus:—Pilot house orders full speed ahead. Engine room replies by bringing arrow attached to handle to the same order. This latter is performed before the actual movement is given to the engine. The markings on the dials are usually of the same character, namely: "Stop," "Stand by," "Slow," "Half speed," "Full speed," "Ahead," and the same "Astern." The dials used on naval vessels differ a trifle, thus: "Stop," "Slow," "Half," "Full" on back motion, "Slow," "Half," "Standard," "Full" on ahead motion. The dials of the transmitters for naval vessels, on account of gun shock, are made of a cast-brass frame work with the openings filled in with heavy transparent celluloid. Those for the merchant marine are fitted with white porcelain, the orders filled in with black enamel. They are illuminated by electric or oil lamps of small candle power. The receivers in the engine room are entirely of brass with the orders deeply cut in and filled for the "Ahead" and "Stop" divisions with black enamel and on the "Astern" divisions red. The dials of standard transmitters are 12 inches in diameter and receivers about 16 inches in diameter. Smaller sized machines are recommended only for small craft, such as have pilot-houses too small to accommodate the standard sizes.

These instruments naturally superseded the ordinary brass gong and jingle bell in so much as they were the more readily operated and provided a great reliability. To-day steamship rules require and naval vessels carry gongs and jingle bells as auxiliaries to the mechanical telegraphs in case of derangement of the latter. They are also required by law to have a "tube of proper size so arranged as to return the sound of the gong to the pilot-house." This practice is justified by experience. The detail as will be clearly recognized is truly serious; for not only is human life endangered, but incalculable damage will result if these signals are not correctly transmitted when docking the vessel.

Working upon the same principles as described above and resembling in outward appearance the engine telegraphs, there are installed on merchant vessels docking, steering, helm, and engine direction telegraphs. Docking and steering telegraphs are usually combined in one instrument. Two handles are employed, one on the right hand and one on the left hand of the head, the dial on one side giving the steering orders in degrees of the helm and on the other side the requisite orders for docking. The two instruments, one located on the navigating bridge and the other aft near the hand-steering wheel, are identical. They are not arranged for reply but can transmit signals in either direction. The orders for docking are interesting to a land-lubber because of their peculiar sailor characteristics, namely: "Stop engines," "Slow ahead," "Slow astern," "Not clear," "All clear," "Heave away," "Slack away," "Hold on," "Let go," "Make fast," "Avast heaving," all expressions which, floating back in memory to the days of the wooden ship of small dimensions, were transmitted through the air by the sonorous voice of the captain, whose orders echoed back from the obedient quartermaster. To-day no sound is heard. The scene has lost its dramatic interest.

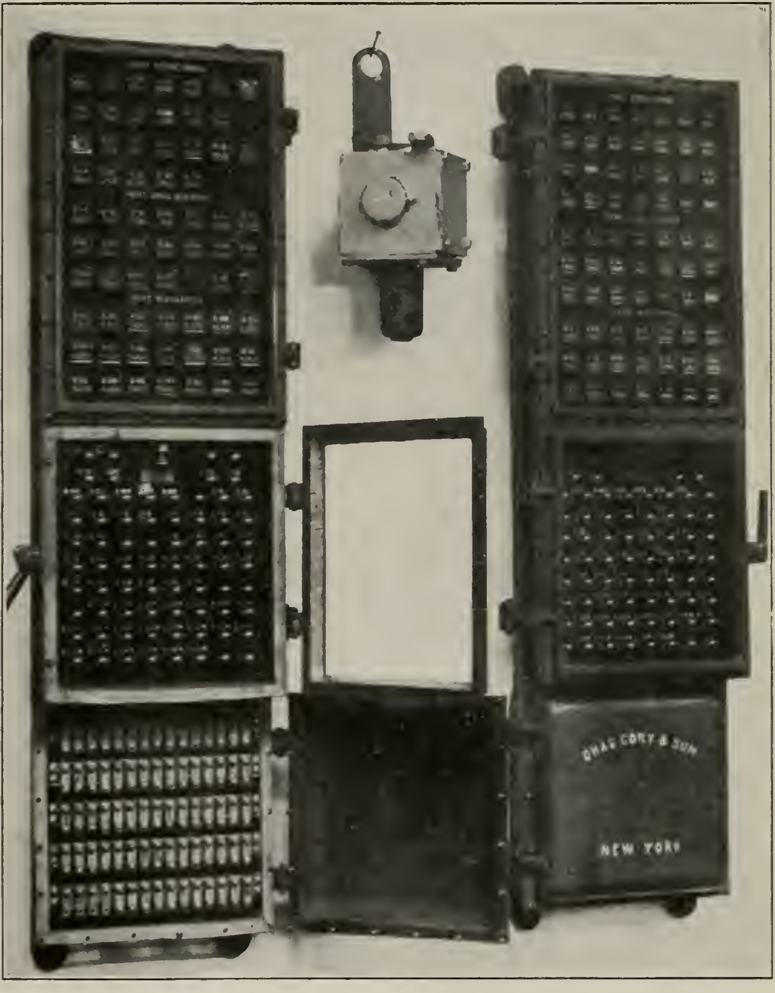
A band attached directly to the rudder stock indicates in the pilot-house or on the bridge the exact angle of the rudder. This is the helm indicator. In like manner the engine direction indicator is connected to the reversing shaft of the main engine so that automatically the signal is transmitted when the engineer sets his engine for the given direction. Docking telegraphs are not in service on naval vessels at the present time, but steering telegraphs, helm indicators and engine direction indicators are customarily installed. Here electrical telegraphs take the place of the mechanical. They will be described subsequently more in detail.

Voice tubes of brass are required by law as auxiliary to the engine mechanical telegraphs. The law is usually fulfilled on merchant vessels by such communication between the pilot house bridge and engine room and also between the chief engineer's room and the engine room. On naval vessels the requirements far exceed this and will be treated later. The reliability of the voice tube between the engine room and bridge is altogether shattered by two elements which have not been overcome to-day, and which, as can plainly be seen, are almost beyond solution—the internal vibrations and noises of the propelling machinery and the wind whistling down the pipe from the exposed position of the tube on the bridge. For this latter cause swivel mouthpieces have been tried with no appreciable effect; for the former, insulated cushions where the tube attaches to hull have been employed with only greater detriment. Flexible rubber mouthpieces of three or four feet in length are installed at certain termini for convenience and portability.

The steamboat inspection service makes the telephone a requirement on certain types of vessels. " On all steamers where the distance is more than a hundred and fifty feet between perpendiculars of pilot-house and forward part of engine room, there shall be communication by means of a telephone between the pilot-house and engine room, such telephone to be installed in lieu of a speaking tube." This condition will inevitably arise in vessels where the engines are located far astern or on vessels of unusual length. With the exception of this telephone circuit, all other telephone communication is optional and employed only for convenience. The development of the telephone for merchant vessels has not only been curtailed, but almost shattered by the falling off in construction of such vessels in this country. The memory must be strained to recall the last transatlantic steamer of American construction, and coastwise steamers for passengers and freight are few and rare. A glance at American shipping for the last two years will readily convince. The shipyards of the country for this period have been sustained mainly by the government. An exact description, therefore, of the telephone installed on passenger and freight vessels must be at least vague. Later it will be seen that this important land instrument has been adopted in the United States navy and a steady development has succeeded. This development work, like many others, has an immediate and intimate effect on the merchant marine. Illustrating this the writer installed some two years ago on a coastwise passenger steamer eight intercommunicating telephones. These instruments were relied upon to the extent of omitting the mechanical docking and steering telegraphs. They also established convenient communication for the captain and chief engineer. At that time the navy was experimenting with what is known as the "loud-speaking" telephone (some authorities consider this a well-sounding phrase), which has now been superseded. This type of telephone was adopted for the case in hand. The system, as far as the telephones were concerned, was a common battery, three-wire circuit, other wires naturally being installed for the intercommunicating feature. The telephones for exposed places and where the noises were excessive were entirely enclosed in water-tight brass boxes. To exclude external sound as far as possible double arm receivers made flexible for convenience extended from each side of the enclosing case. The non-water-tight telephones usually installed in the staterooms had all their parts directly attached and were self-contained. The delicate parts were also encased, but mounted in a hard-wood frame. A revolving lever brought the transmitter into circuit. These telephones would in nearly every case reproduce the human voice to such intensity that it would be audible some six or seven feet away from the instrument. In other large installations of telephones on shipboard recurrence to land practice usually prevails. Switch boards for ordinary land service are installed, and either batteries, or batteries and generators, included therewith. The problems involved will be better understood in viewing the development from a naval standpoint.

As a system of convenience, just as in land practice, the ordinary call-bell with push-buttons is without a rival. As an adjunct to the voice-tube system it maintains the dignity of its importance, although on many merchant vessels its place is filled by a whistle in the voice-tube mouthpiece. Annunciators resembling those found in offices and hotels are manufactured with a drop of such design that the rolling and vibrations of the vessel will in no way affect their proper and accurate operation. For above all things a system of convenience must, as such, work consistently. Despite all the wonders of electricity and all the development by all the mighty minds, if you press a button and there is no result therefrom, you not only become an atheist, but a positive pluperfect anarchist. With push-buttons made of water-tight pattern where exposed to the weather or rough usage, with innocuous ones in the better part of the ship and with well-designed annunciators, the call-bell system not only possesses an enviable and convenient position, but also is as indispensable to the comfort of the passengers and officers as the pleasant quarters or the agreeable cuisine.

FIG. 1.



Metallic thermostat and thermostat annunciators.

The distinction between the mechanical instruments used on naval vessels and those employed on merchant ships has been punctuated. There are three systems of such communication that are not ordinarily fitted on the latter type of ships, but which are never omitted from battleships, namely, fire-room telegraphs, blower telegraphs, and turret-hoist telegraphs. The principles of their operation and methods of installation remain the same. Turret-hoist signals were only lately changed from electrical to mechanical, due to the sluggishness of the carbon filament incandescent lamps as compared to the increase in speed of the hoist, the latter lifting the charge from the handling-room to the gun breech in five seconds. The signals are very simple, to wit: "Hoist," "Lower." The fire-room telegraphs control the management of the fire-rooms (or boiler-rooms). For the accomplishment of this purpose their dials are accordingly designed. They read as follows: "More feed," "All right," "Less feed," "Stop firing," "Priming," "Stop," "Slow,' "Full speed," "Start auxiliary feed," "More steam." In battleships, where the design of the compartments has required that the forced-draft blowers be located at some remote place as regards the fire-room floor, the use of telegraphs was occasioned for the purpose of producing more or less draft as the conditions might demand. The regular fire-room telegraph has been requisitioned for this object with naturally its dial readings changed to those which would follow from the application. The signals indicate to the operators at the blowers to increase or decrease the speed of the motors. Electric motors are now the prime movers for these auxiliaries instead of steam engines. Mechanical gongs and jingle bells for the operation of the anchor windlass engine, ash hoists, and on the transfer platforms of the turrets complete the signals that are not either electrical or electro-mechanical, if the latter classification include the voice-tube system.

To the questions of pure electrical engineering there is augmented on naval vessels the important factor of military efficiency. Expanded this means that all apparatus must be so designed that it will be accurate and trustworthy under any and all conditions of war. That the material and instruments must withstand shocks from within when the vessel is offering her defense in action and will maintain stolidly the hot shells of her enemy in return. Development on military lines is perforce gradual when the basis of the movement revolves around the theory of battle. War is by good fortune quite rare in these "piping times of peace." But as the wise nation must prepare for war in time of peace, the development work on military lines can advance only by the observation of past naval engagements and sensible deductions from them. It might be generally stated that these interior communications divide themselves into those which are used for the ordinary peaceful movements of the vessel and those which are useful and necessary in time of actual conflict. For the purpose of being continually prepared these latter signals are always employed in drill and gun practice. With such accumulation of systems it does occur that certain ones make themselves factors in both cases to such a degree that it would appear that no taxonomy could be assumed. Such systems as the call bells, telephones and voice-tubes illustrate this clearly. These systems are just as important in battle service as in peaceful cruising. The following arrangement, though open to question, will be adopted for the purpose of this discussion:

Systems employed for both battle and cruising: *
- *a*. Engine revolution telegraph.
- *b*. Engine shaft revolution indicator.
- *c*. Steering telegraph.
- *d*. Helm angle indicator.
- *e*. Fire-room timing.
- *f*. Call bell.
    - Exposed.
    - Unexposed.
- *g*. Voice tube.
- *h*. Telephone.
    - General.
    - Engine and fire-room.
    - Bridge and engine room.
    - Battle.

Systems employed during cruising only:
- *a*. Fire alarm.
- *b*. General alarm gong.
- *c*. Anchor handling and boat hour gong.
- *d*. Warning signal.
- *e*. Fuel oil tank indicator.

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* It must be held in mind that these systems are available under all conditions. The writer adopts this classification merely for convenience.

Systems employed during battle only:

- *a.* Broadside ammunition hoist.
- *b.* Broadside salvo-firing.
- *c.* Turret salvo-firing.
- *d.* Cease firing.
- *e.* Gun firing.
- *f.* Torpedo firing.
- *g.* Gyro indicating.
- *h* Range and deflection.
- *i.* Local turret gun firing indicator.
- *j.* Turret danger zone.

It will be noted that of the systems enumerated nearly 50 per cent. are devoted to the control of the guns. Later it will be brought out that besides these special systems the telephone and voice-tubes are important factors to-day in the naval war drama.

At the present time electric engine revolution telegraphs, steering telegraphs and helm angle indicators are designed after the "lamp pattern" type of instrument. They are identical in their method of wiring and general design, so that a description of one will suffice for all. Engine revolution telegraphs are designed for the purpose of increasing or decreasing the speed of the vessel during squadron formation.* The vessel being under orders for maintaining standard speed, this being indicated by the mechanical telegraphs, one, two, three, or four more revolutions, will be signalled by this electrical telegraph. On the bridge the transmitter of the pedestal type, by the operation of moving a handle around the circumference of the head, rings a bell and lights a lamp in the engine room, which latter signal requires the moving of a similar handle on the engine-room indicator to the revolutions desired. This done, the lamp in the transmitter is lighted, giving assurance that the signal has been received and the operation accomplished. The contact-maker in the transmitter or indicator consists simply of carbons which are revolved by the handle across insulated copper segments to complete the lamp circuits. The older type of instrument required the rapid

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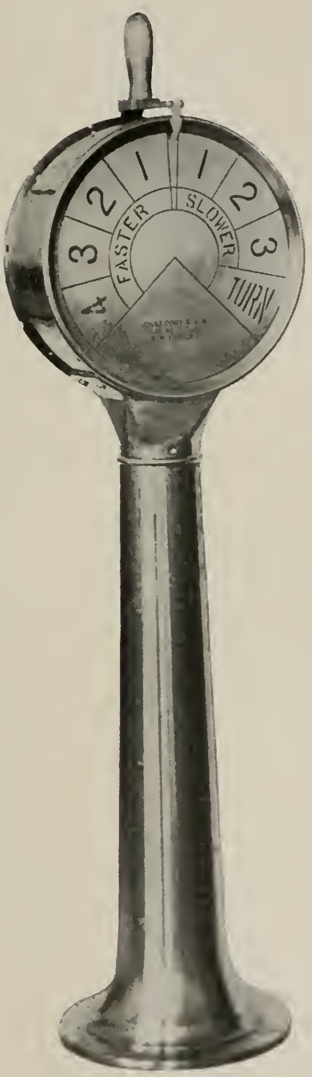
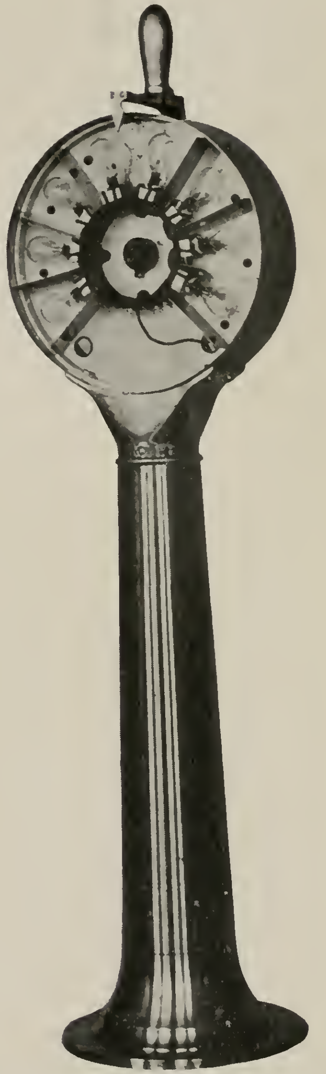
* The adoption of steam turbines for propelling purposes now requires an entirely new design of instrument, due to the lack of close control of turbine speeds and increase in propellor revolutions. Therefore these instruments are designed to transmit any number of revolutions. The proposed type is similar to the familiar "carriage call" device.

FIG. 2.



Engine revolution transmitter.
Electric lamp type.

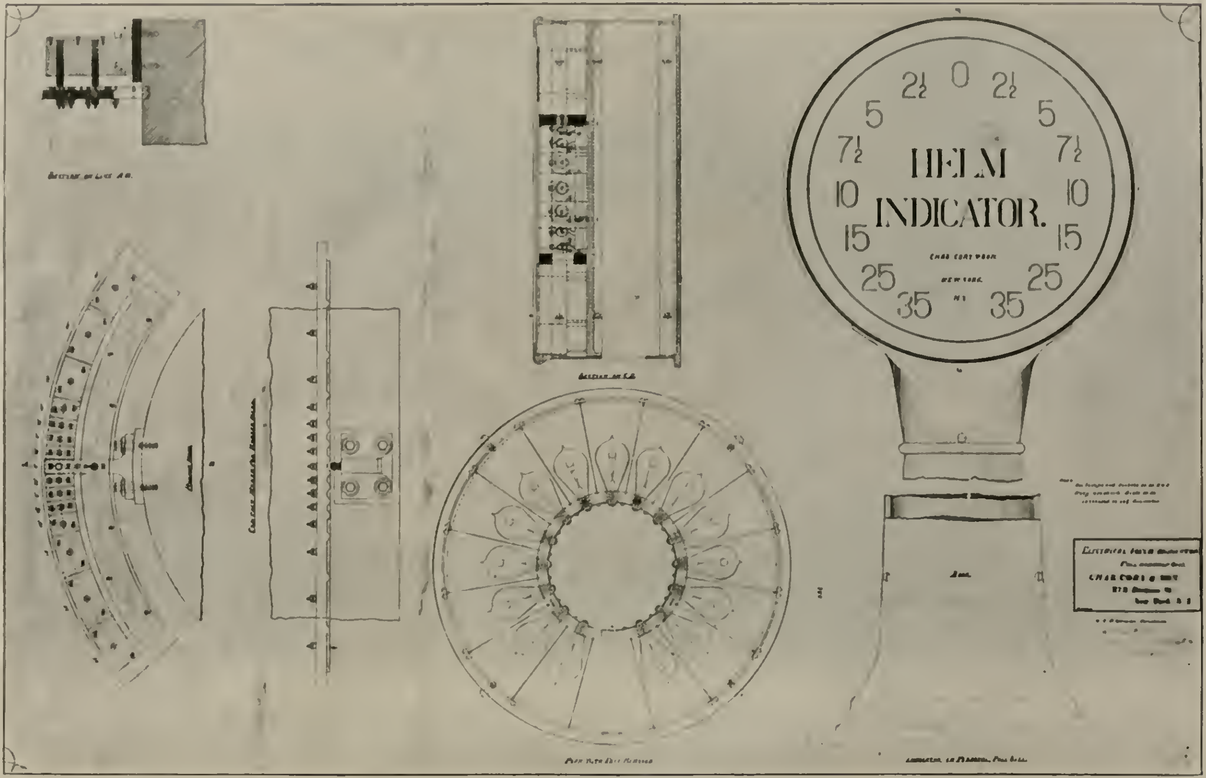
FIG. 3.



Engine revolution transmitter. Electric lamp
type with dial removed.

movement of the handle of the transmitter or indicator for the purpose of operating a magneto-generator to ring the bell, but the latest design provides bells designed for 125 volts, the standard used in the United States navy.

Fig. 4.

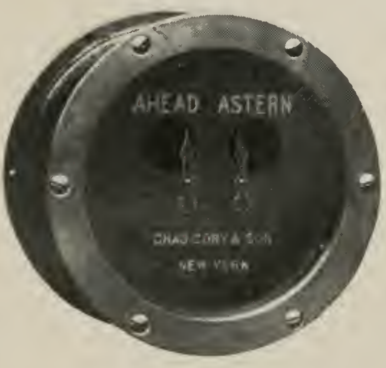


Electric helm indicator and transmitter. Lamp type.

In like manner steering telegraphs * of the pedestal and bulkhead type are installed on the bridge, in the steering-engine room, and central station for giving signals, usually in degrees, for the proper manœuvring of the vessel.

The helm indicators are built on the same lines, are located in the same places, and are for purposes of signalling the number of degrees the helm makes when the rudder has been actually moved from the midship line. The indicators are all wired in parallel with the transmitters, but are so arranged with cut-out switches that only those indicators desired may be in service. The transmitter is located near the rudder stock and the contact arm directly attached thereto. Carbon brushes move over insulated segments of copper, which are designed in accordance with the mechanical arc through which the rudder moves. The vital parts of these instruments are enclosed in water-tight brass cases, which carry with them sufficient protection from mechanical injury.

Fig. 5.



Engine shaft speed indicator.

Engine-shaft indicators are located in the pilot-house and central station and by direct mechanical attachment to the main engine-shaft permit the direction and number of revolutions of the engine to be read at any time. The dials of the indicators now made of brass are marked " Ahead " and " Astern." Be-

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* The dials of the steering telegraphs have recently been changed to read as follows: " Amid," " Course," " Steady,' " Starboard," " Port," " Meet Her," " Ease Helm," " 5 Degrees," " 10 Degrees," " 15 Degrees," " Standard," " Hard Over."

tween these indicators rests a pivoted arrow actuated by a double set of magnets. As these magnets are put into circuit by the transmitter they move the arrow intermittently either to the right or left, marking thus each revolution of the shaft. With a stop watch the revolutions per minute may be easily and quickly noted. The shaft-speed transmitter has received very beneficial development in the past three years. From a device, which was not only very careless in its operation, but so overworked that its parts could not stand the continued strains, there emerges an instrument thoroughly reliable and not apt to lead to the engineer's increase of vocabulary. A worm-band is securely fastened to the main shaft, into which engages a worm-wheel. This latter by an extension shaft carries and operates the electrical contacts fixed on a drum. The worm-wheel revolves once for every ten revolutions of the main shaft, thereby lessening greatly all strains. The electrical contacts can be so arranged that they mark every revolution or any proportional number. The brushes, as in the other instruments, are of carbon.*

While great improvements are made in important large systems and apparatus, it is remarkable how long crude methods remain by which the desired results are attained. Contractors for battleships are required to demonstrate that the vessel will under certain stipulated conditions acquire and maintain a guaranteed speed. It can be plainly seen that the greatest requisite to meet this condition is sufficient and constant steam pressure. Passing from this stage the smooth and regular firing of the boilers becomes the point of vital interest for the accomplishment of the result, of interest not only to the builder but as well to the owner, for he also desires that the vessel be capable at all times of producing this guaranteed speed. Until recently the method employed was by word of mouth from the engine room with men calling off the time intervals from watches, these latter posted in each fire-room. To-day these signals are automatically and chronologically regulated and transmitted from the engine room to each fire-room. The transmitter consists essentially of a small motor driving through gear and two steel discs a drum containing on its periphery contact segments. Between the steel discs is placed a raw-hide pinion movable from the circumference of the disc to the centre. By varying the position of this pinion the revolutions of the contact drum are controlled. A graduated pointer on the exterior of the water-tight case permits the interval of firing from twenty seconds to ten minutes. This transmitter is connected by a cable of wires to the various indicators, one usually in each fire-room. These are designed to produce both aural and visual signals, *i.e.,* a large gong and incandescent lamp. They are about 14 inches in diameter, marked with raised letters " Fire Furnace No. —" above a small opening. In the interior a brass dial cut with the figures of the furnace numbers is revolved by a ratchet movement accomplished by magnets, as they are energized by the closing of the circuits controlled by the transmitter. In this way the number appears in the opening of the indicator simultaneously with the sounding of the gong. This is the simplest system that has found favor at the present time, although there are others which, being more complicated, still provide the same results.

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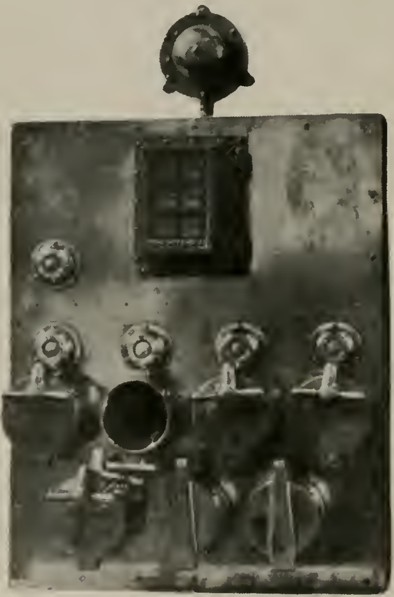
* This instrument is now to be superseded by a direct reading instrument —designed to indicate continuously any and all speed changes.

Employed for use in the officers' quarters the call-bell system is one entirely of comfort and convenience. The various pantries and orderlies are supplied with annunciators connected with push-buttons located in the officers' state-rooms and offices. This system divides into groups corresponding to the military grouping or rank of the officers. There are calls for the admiral and captain, ward-room calls, junior officers' calls and warrant officers' calls. Since the general change in type of installation from moulding to conduit, the design of all annunciators, push-buttons, and accompanying appliances take the prevailing characteristics of water-tightness. The annunciator drops are carefully constructed on the gravity principle with sufficient safety to protect against false signals due to vibrations or gun shock. The call-bell system, which operates in conjunction with the voice-tube system, is sharply divided for military safety into exposed and unexposed calls. In such manner the circuits that may be required in the opening of an engagement, and thereby made useless when the conflict rises to its height, will not make unavailable those circuits which in the interior of the vessel are still of vital necessity. It is the practice to duplicate the call, that is, that a push-button and bell are required at both ends of the voice-tube. As may be surmised, it often transpires that many voice-tubes with their calling apparatus meet in one compartment. This leads to a system of stations located at important points throughout the vessel. At these stations it is convenient to group all the voice-tube mouthpieces, push-buttons, bells, or buzzers and annunciator on a brass panel. This preserves space and produces an excellent installation. The push-buttons are all carefully labelled so that communication can be quickly and, with the aid of the annunciator, intelligibly established.

It may be written without fear of contradiction that voice-tubes parallel every important system of interior communication.

FIG. 6.

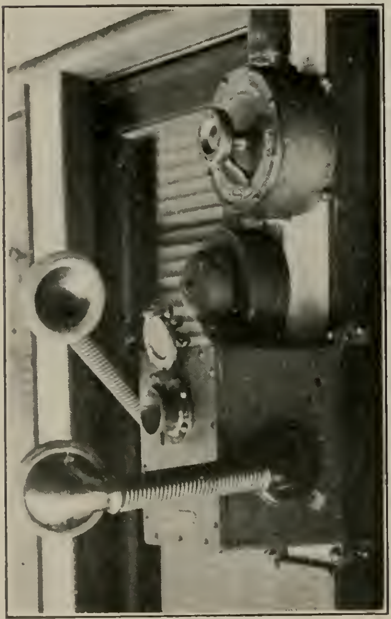


Call-bell and voice-tube panel.

They are seamless hard-drawn brass tubes varying in external diameter from 1½ to 4 inches. Tubes vary in thickness for the purpose of mechanical strength, those which are led in straight runs No. 20 B.W.G. and those for bends and where subject to mechanical strains No. 14 B.W.G. Where tubes connect two terminal points by a direct path, or of a large diameter, so that they may be utilized for shouting-tubes, or when they are employed for gun-firing control, they are not provided with calling arrangements as above explained. Certain of these tubes are fitted with whistle mouthpieces in lieu of the bell and push-button. Mouthpieces differ in design for nearly every condition of use, and only a detailed description could fairly represent and explain them. Indeed, as new conditions arise, or more efficient methods present themselves, the mouthpieces are immediately attacked and the old types ordered into exile. Between compartments that are water-tight special mouthpieces of water-tight design are installed; between non-water-tight compartments, or non-water-tight and water-tight, a simple covered or open type. For shouting-tubes, usually 3 inches or 4 inches in diameter, a design of the pattern of a megaphone is preferred. In the boiler rooms, where the forced draft occasions a disturbing pressure, the design provided is that of a diaphragm in the mouthpiece, which can be only affected by the human voice. The tubes used solely for the control of gun-fire are arranged so that a long flexible tube can be plugged into the permanent mouthpiece. This flexible tube ends in a headgear containing in some conditions only two ear-pieces and in others the addition of a mouthpiece. This design permits the men at the guns to have the freedom of their hands, at the same time receiving direct aural orders from the officer in charge of the guns. It will be observed later how this system has taken its cue from the present adaptation of the telephone for this like duty. To obtain the greatest good from the voice-tube system extreme care is observed in all requirements of its installation. Those points of inefficiency which were indicated in the description of this system for merchant vessels are overcome as far as possible in naval vessels. The navigating bridge is in most recent designs entirely enclosed, and the voice-tube connecting the engine room, irrespective of other considerations, is led in the most direct line to the engine-starting platform. Machinery noises and vibrations are not, to be sure, entirely overcome, but every effort is exerted to accomplish the intelligent transmission of the voice. The criterion at the present moment must appear in the abundant and important uses that our navy finds for their increased employment.

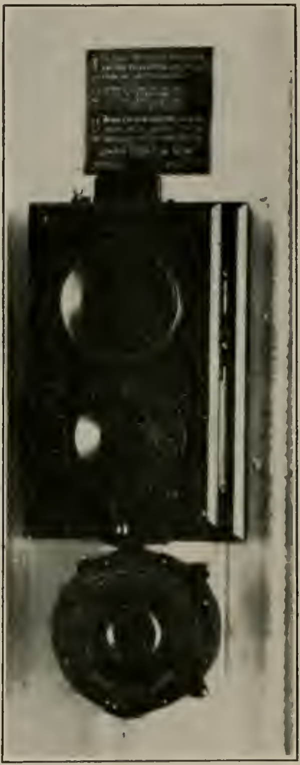
Retrospectively the development of the telephone on battleships is remarkable. As late as 1903 a few telephones of the commercial type were installed merely as a matter of experiment. They consisted simply of a box telephone with transmitter and receiver on a hook such as were prevalent in office buildings, encased in brass for protection in exposed places. Their use was purely a matter of convenience, doubtless little reliance being ascribed to them. The patents covered by the Bell Telephone Company nearing proscription, other parties began experiments for a suitable telephone for marine purposes. The question had not been largely discussed nor experimentation fruitful. However, one observation, that of noises within the vessel, conspired to the design of a telephone which would by its volume, or intensification of the human voice, and by the exclusion of external noises compass the solution of the problem. This type of telephone was designed, as had been its predecessors, to mount on bulkheads. All portable receivers were discarded and the instru-

FIG. 7.



Water-tight type "loud-speaking" telephone.

FIG. 8.

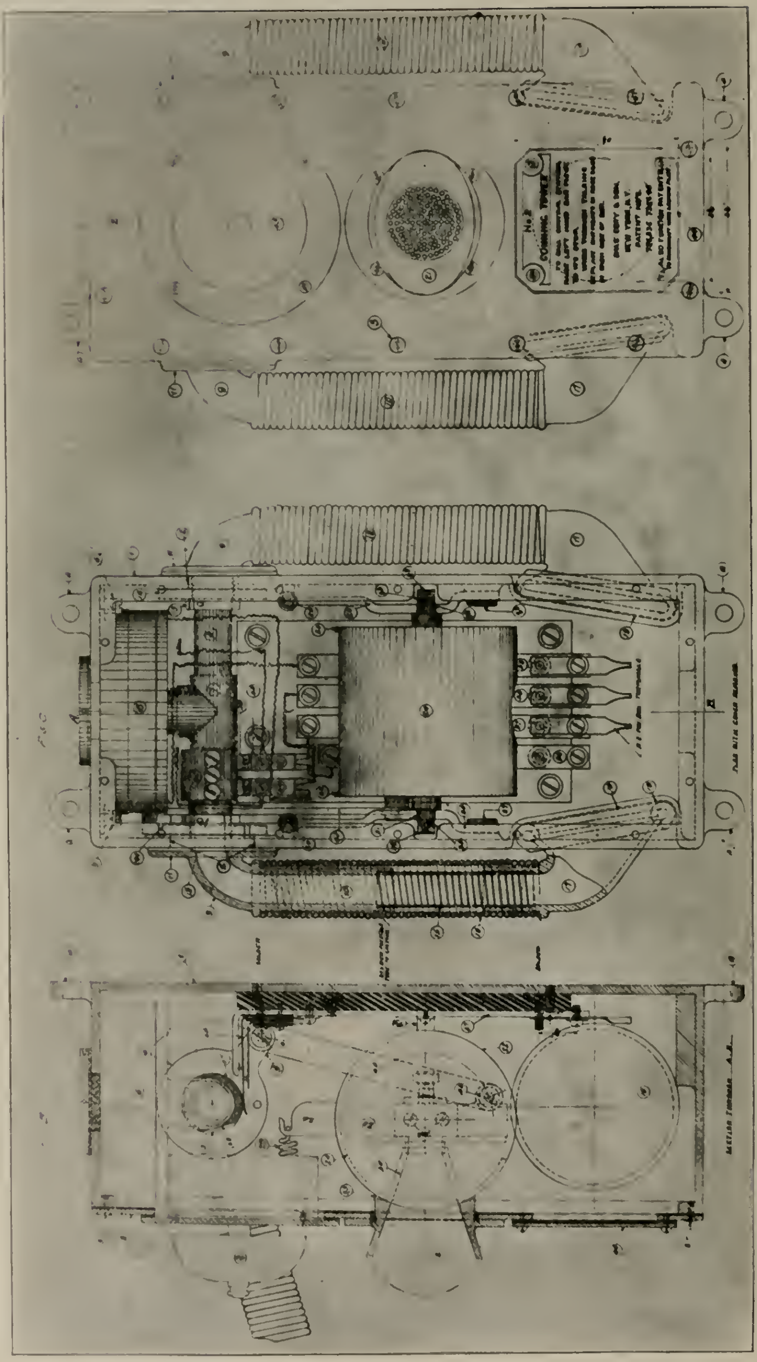


Non-water-tight type "loud-speaking" telephone.

ment performed its functions with as little human aid as possible. Double receivers to exclude sounds other than the established circuit would permit were an important adjunct to the water-tight type. The non-water-tight type, as explained previously, could speak so audibly that it was unnecessary to place the ear to the receiver or to hold the lips near to the transmitter. The receivers were wound for a low resistance, so that the energy necessary was that of a few batteries, usually five. These telephones supplied communication for the general service, and were therefore, interconnected as desired by a water-tight telephone switchboard located in the central station. This telephone switchboard is interesting. It is still employed. No cords or plugs or jacks can be found on it. This will probably surprise our telephone engineers. All the interconnections are made by small "throw-over" or "tumbler" switches. Other features of the board are recognizable, night-bell, visual drops, clearing-out drops, operator's head-set, etc. The circuits were divided up into groups of five, which for a forty-line board and the general use of the system on shipboard was found to be ample.

But to return to the telephones. It was early pointed out that though ships' noises did affect the hearing qualities, vibrations transmitted to the various bulkheads acted more to their disparagement and disuse. Coupled with the interferences of the proper hearing qualities, came the effect of the packing of the carbon granules in the transmitters. These two salient objections told upon the advantages thought to be realized in this excellently made telephone and led to the types now specified and installed. No stint of praise should be allowed to the achievement of the "loud-speaking" telephones, for in their passing they have confirmed the telephone for yet greater service—that of controlling the engines of war. So the order was issued that all telephones must be taken off of bulkheads; no more low-resistance receivers; back to the standard voltage in commercial practice and back to a simple two-wire system. From a system depending only on batteries without any intervening coils, emerges a system replete with condensers, induction coils, alternating current ringer, etc. Another step in advance breaks up the whole into four distinct divisions: A general telephone system for the convenience of the officers; a special and independent set of circuits connecting the fire-rooms and engine rooms; another special

FIG. 9.



External and internal view, "loud-speaking" telephone. Water-tight type.

circuit between the engine room and the bridge; and last, but by far the mightiest, an elaborate system for the control of the guns during battle.

In the officers' state-rooms and compartments, where the telephone is not subject to exposure, the hand telephone set consisting of one transmitter and one receiver is suspended when not in use from a water-tight case which contains the condenser and bell mechanism. The act of taking the telephone down for use, or returning it thereafter, automatically operates a switch on the top of the case which establishes the circuit to the switchboard. The water-tight telephone is similar in operation, differing only in that the telephone hand-set is enclosed in a stowage box; when this is opened the circuit is established to the switchboard. The telephones connecting the fire-rooms and engine rooms are like the water-tight type used on the general telephone system with this difference, that no bells are provided. The system does not pass through the telephone switchboard, and therefore the calling apparatus is taken from the general interior communication system, consisting of direct-current bells and push-buttons. The circuits between the bridge and engine room are direct, as in the latter system, having no connection whatever with the general telephone system. The telephones are exactly the same as those installed for gun control. The live wires are brought to a terminal in a brass box, which serves as a permanent fixture wherein to stow the telephone set. A portable twin wire is led to two receivers wired in multiple arranged to fit comfortably on the head. By means of a hard-rubber plug and jack cut into the portable twin conductor a breast type of transmitter may be introduced to complete the outfit. This permits the use of the hands and produces continuous communications. The breast transmitter has a vertical adjustment of three inches, a back and forward movement of 30 degrees and a side movement of 180 degrees. Energy is supplied to all of these systems, including the battle telephones, through a transfer panel located in the central station. There is further provided for the bridge and engine telephone circuits a transfer switch, so that the exposed circuit to the bridge may be cut out in case the bridge is destroyed in action, and communication safely maintained from the central station. It would only weary the reader to describe each and every sub-division of battle telephone system unless he were deeply interested in military questions. Such information he would hardly seek from this paper. As nearly every battleship differs as to her complement of guns, their arrangement or calibre, it is evident that a description of one particular vessel would not apply to others. Suffice it to add, therefore, that in general there will be found a separate and complete system for the guns of large size mounted in turrets; one for the secondary battery (or torpedo-defense guns); one for searchlights which are necessary for torpedo defense at night; one for torpedo firing; and one for the exclusive use of the range-officer. The utilization of these battle telephones will be more clearly appreciated when shown later in conjunction with their correlated system of fire control.

Of the systems which are not actually necessary for military operations unquestionably the fire-alarm system is the most important. Until recently metallic thermostats, acting upon the difference of the expansion of two dissimilar metals, were installed in all the coal bunkers, magazines and store-rooms; but this type has been found deficient in many ways and so has been superseded by a simple mercurial type. The circuits from the thermostats are all led to annunciators constructed like those for the call-bell system, having as an auxiliary a switch for each line in order that the bell may be cut out of circuit after an alarm has been given.

The general alarm gong system, consisting of two or three contact-makers and 30 odd 12-inch electric gongs, serves the purpose of calling the crew to drill or arms or giving an alarm in case of danger.

The purpose of anchor handling and boat hour gongs is implied in their names. The gongs are usually 8 inches in diameter and are actuated by push-buttons. The former give directions from the forecastle deck for the control of the anchor windlass engine; the latter provide a call notice to the officers' quarters that the shore-cutter is ready to depart.

A warning is provided for the closing of all water-tight doors in cases of collision. The necessity here is for a sound that will be distinguishable from the noises of machinery. The first means devised and one long used was that of an electric magnet compressing enough air and allowing it to escape through a shrill whistle. The sound produced greatly resembled the familiar chirp of the cricket. This has now been superseded by what is known as the electric "howler." A magnet actuates a hammer against a tight pigskin diaphragm, the noise being intensified by a horn such as seen on automobiles. The sound is not as shrill as the whistles, but is sufficiently differentiated from the ship noises to be entirely satisfactory.

In vessels carrying oil for fuel it becomes evident that some indication must be given as to the height of the oil in the tanks when filling same. An ordinary float in the tank provides the switch for closing the necessary circuits. Indications are shown on an annunciator of the ordinary type.

It is essential among the systems purely for the control of the guns that primarily provision be made to quickly handle the ammunition. For the large turret guns it has been explained that mechanical signals are employed. In the case of the secondary battery, although voice-tubes allow verbal signals to be transmitted, there has lately been installed a system designated as broadside ammunition hoist signals. The indicators consist of a simple brass water-tight case with round white discs properly marked and illuminated by 5-candle power incandescent lamps. The markings provide for signals to hoist, lower and stop as well as to determine the kind of ammunition desired. Transmitters consist of several standard switches mounted in one case and properly designated. As a check a similar indicator is installed at the loading end of the hoist and the lamps wired in series, the transmitter with indicator being located at the upper or receiving end of the hoist.

In order that the turret guns and secondary battery may fire a broadside simultaneously, systems of bells, buzzers and contact makers have been designed. These systems have been nominated respectively for the turret guns—turret salvo-firing, and for the smaller guns—broadside salvo-firing. Small 3-inch electric bells are permanently installed in and about the guns so as to be distinctly audible; they give the order to "stand-by." Portable buzzers strapped to the chests of the gunners are operated by push-buttons and give the signal to "Fire." The contact makers and push-buttons are located at the two principal fighting-tops, the captain's battle station and the sub-stations. The point interesting to note in this system is that of strapping the buzzers to the gunners. This is done in order that there can be no mistake in the interpretation of the signals, for though it may not be audible, the vibrations of the buzzer will be communicated to the body.

The cease-firing system is identical to the general alarm system. The diameter of the gongs for this system is made 10 inches instead of 12 inches. On some battleships in order to better differentiate the sound one system will have vibratory gongs, the other single-stroke. This system provides signals to commence and cease firing and pervades the entire vessels. Thus it is a general gun signal.

At the present writing the actual electric firing of the guns from the vessel's electric plant has never been required. The guns are provided with a local battery system and the consideration to-day is not only to retain this means, but also to provide a similar system taken from the vessel's permanent installation. Special motor generators are to be designed so that only the requisite voltage and current will be delivered to the guns. Switches of a portable type, receptacles for connection at the guns and other necessary appliances will be furnished. No details have yet been considered, and it is problematical whether such a system will not in the end find much objection in the opinion of those vitally concerned.

Morale in warfare is an important factor. The enemy must be more or less affected by what he estimates as the fighting strength of his opponent, or what the latter may hold in reserve as reinforcement. So there are retained in our large battleships at least two torpedo tubes. From stations located on the superstructure deck the firing of the torpedos is not only directed but actually accomplished. Firing keys, not unlike telegraph keys, are located at these firing stations in conjunction with signals that permit no complication before the firing keys are actuated.

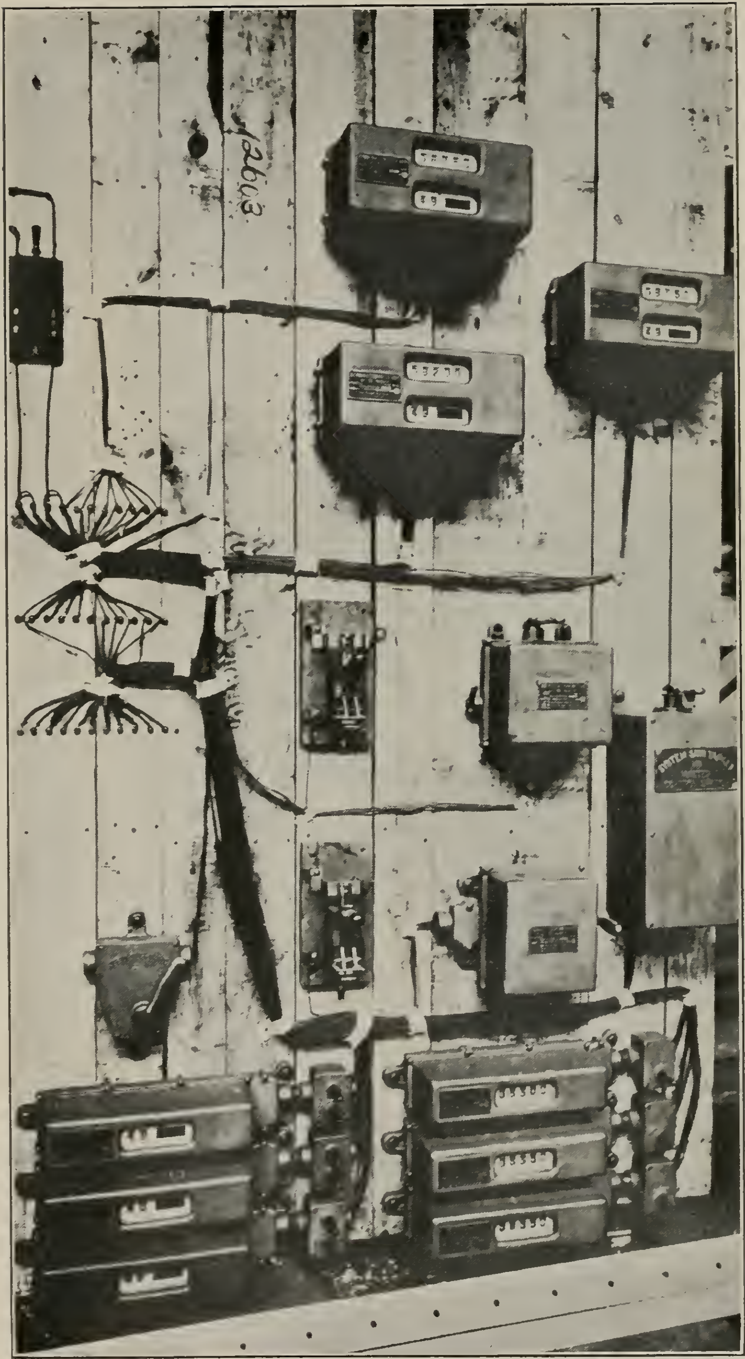
To give the necessary directive action to the torpedoes a system of telegraph indicators and transmitters of the lamp pattern, as described under the head of electric engine revolution and electric steering telegraphs, is installed—one transmitter at each torpedo firing station with indicators at each torpedo tube. These transmitters indicate at the torpedo tubes the number of degrees from zero centre reading to 90 degrees port and starboard. This system bears the natural title of the gyro-indicator system, as by this means the torpedo gyroscope is so adjusted.

Of all essential matters in battleship design that of properly controlling the fire of the guns is without question the most important. A battleship is primarily a fighting machine, and therefore the necessity of so controlling the gun fire as to obtain the greatest battle efficiency. This subject of fire-control has called forth every consideration by the naval authorities, and investigation, experiment, and money have not been spared in providing the most reliable systems suggested. Every idea that was worthy a passing notice has been given due trial and the liberal spirit of the government to-day would gladly respond to any suggestions whereby greater improvements would result. To clearly understand the arrangements now provided on the latest battleship designs some reference must be made to the arrangement of compartments and the disposition of the guns. The design of recent battleships has been rightly dubbed the " all big gun " type. Our most powerful battleships, those of over 21,000 tons displacement, carry five turrets, containing two 12-inch guns in each turret. Two are located forward, one raised slightly above the other, and three aft, two on the same level and one slightly raised above them. The 5-inch guns used for defense against the attacks of torpedo boats are distributed at important points on the gun deck. The range, deflection, and battle orders for these guns are communicated solely by telephones, as referred to in the description of the telephone system. Not only are the 12-inch turret guns supplied with telephones for this purpose, but also with special instruments for visually presenting the range, deflection, and battle orders continuously before the sight setters and gun trainers.

The orders all emanate from what are called sub-stations, compartments well below the protective deck and water-line, sheltered in every possible way from hostile shell. The range-finding instruments are located in lofty towers, one forward and one aft, with their respective " spotters " and range officers. The spotters, watching each shot as it falls and gauging the range and deflection, communicate directly with the sub-stations by means of the telephone. The range and deflection transmitters in the sub-stations are immediately called into operation and in turn send forth to each gun the proper order. The problem contains another factor. In naval warfare both parties to the conflict are in motion, and by virtue thereof the range is constantly varying. For this condition there is provided in the sub-stations a range clock carrying a rate of change disc, by means of which the rate of change of range may at all times be marked. This range clock has a maximum reading of 14,000 yards. When the shot-spotter reports from the fire-control tower, the rate of change of range is set on the clock. The clock continues then to mark off regular ranges which, through the proper official, are then communicated by the range transmitters to the guns. Deflections are noted by the same shot-spotter and in the same way transmitted through the sub-station to the guns. Deflections are measured in yards up to a maximum of 100. Formerly zero was arbitrarily taken at the centre, which required the further designation of right or left deflection. By assuming 50 yards as the zero deflection any number below 50 indicates right and any number above 50 indicates left deflection.

The cause for all this care in firing guns originates from the desideratum of " bunching " the hits. When several guns are firing particularly in range and their shots are dispersed, poor hitting ensues. Therefore such fire-control systems are important and necessary in that they maintain all the sights of the guns set alike while in the act of firing. Two systems for accomplishing this requirement have been experimented with and have shown about equal advantage and disadvantage from a practical standpoint. It is unnecessary to elaborate a description of either system, suffice it to say that one system is designed on the simple incandescent lamp principle, and the other on a system of magnets in conjunction with ratchet-motion escapements. In the former indications are produced by illuminating numbers by 5-candle power lamps; in the latter the range and deflection numbers revolve by increments of 50 yards for range and unit increments for deflection. The latter instruments, though rectangular instead of round, resemble in their movements the familiar fare registers which are seen in all trolley cars. This system provides also for the repetition of the signal after it has been conveyed to the gun at the sending station. Ready means are also provided for cutting out the instruments which may become deranged without affecting the other instruments on the system. This reply or checking feature is convincingly accomplished in the lamp-pattern design by introducing similar indicators at the sending station connected in series with the indicators at the guns. The transmitters in both systems, though the instruments are dissimi-

FIG. 10.



Assembly of fire-control instruments.

lar in outward design, are in principal merely switches for closing the desired circuits. The essential difference between the lamp-pattern and the electro-magnet systems is that the former is purely an electric contact method and the latter an electro-mechanical movement.

The vital importance which attaches to this fire-control system is shown by the regard with which it is installed. With all these instruments located behind and below armor, in the event that the fire-control towers be completely demolished, communication can be transmitted from the captain's battle station, which is a small elliptical armored compartment on the superstructure deck. If again by any chance this invulnerable citadel be destroyed, retirement to the sub-station is offered. This latter place can only be made untenable by the sinking of the vessel. When this happens the hull becomes only a hulk and the engine-of-war becomes a derelict.

The last two systems in this classification, namely, local turret gun firing indicator system and turret danger zone system, may consistently be considered together. They have been required mainly because to-day it is thought one system cannot accomplish all that is desired. And certainly a detailed investigation will convince even the most conscientious designer that a division was absolutely unavoidable. It has been stated that in the " all big gun " design the turrets are disposed, two forward, one above the other and three aft, two on the same level and one above them. With this alone in mind it becomes apparent that unless due provision is made there will occur in time of war, or target practice, exceedingly dangerous interferences, not only by the various positions of the guns, but also by the turrets which carry them. Casually the suggestion would be to guard the turrets and guns by positive mechanical blocking devices; but this is impractical inasmuch as it restricts to an alarming extent the radius of gun action, a restriction which would reduce the efficiency of the fighting qualities of the vessel to a mere show in battle. The guns have a certain radius of elevation and depression, just as the turret has a fixed radius of train on a horizontal plane. One gun or set of guns in one turret, let it be the raised turret, are set for extreme depression, while the guns in the lower turret are fixed at maximum elevation on the same degree of train. If under these conditions the raised turret guns are fired, they throw their charge with disastrous results at the lower turret guns. A change in train of the raised or lower turret would avoid any such mishap. Here it must be understood that the turret gunners are excluded from external view, hemmed in behind 12 inches of armor. The sighting of the guns is accomplished by prismatic telescopes, which present to the sight setters the image of the object upon which they fire. Augment the many interferences which will arise by the above illustration, by the movement of one turret body into the fighting line of an adjacent turret, and the problem is not only magnified to the extremity of hopeless solution, but becomes utterly exasperating. No instruments for this system have at the present time been manufactured. Designs have been drafted in accord with models of guns and turrets prepared to illustrate the many dangerous interferences. It remains for experimentation and actual trial to demonstrate the need or practical usefulness of a system which perforce must carry with it complications proportional with the results to be obtained. Several methods have been suggested; but to the writer's knowledge only one system has found acceptance at the present time. The principle of the design is based on the desire to eliminate at least as much as possible the use of small shafting and permit the signals to be conveyed by electric currents. Yet the method must introduce the mechanical feature, because the every motion of one gun and one turret must be transmitted to each of the other turrets or guns where interferences may occur. The system comprises two sets of instruments, one set based on purely the lamp-signal system—the transmitter mechanically attached to the gun or turret, and similar, save in size and number of contacts, to the other electrical telegraphs—and the other based on a magnet floating in a circumferential group of magnet coils whose poles alternately present a north pole and then a south pole. This, producing a revolving motion in accord with a mechanically-operated contact maker atttached either to a gun or turret, reproduces the movement in another turret. The principle is here briefly stated. The details are not conclusively prepared at present; but the object of accomplishing this work by electrical methods rather than by mechanical are at least set forth. If reliability is found to be more necessary than space, weight, and inconvenience, then the mechanical system will prevail. Thus the entire success of the turret danger zone system must await the final verdict of the future.

Many times during the explanation of the above systems mention has been made of the central station. This compartment is located below the protective deck and covered from danger by armor. Besides furnishing a protected station from which to guide the vessel when the upper pilot-house has been destroyed, it also gives a cover to the necessary switching mechanisms for the supply of current to the interior communication systems. From the captain's battle station, which has been already briefly alluded to, an armored tube three feet in diameter is fitted ending in the central station. This tube protects the steering gear leads as well as the important wires and cables of the essentially battle and navigating circuits. In this room will be found the steering wheel, engine mechanical telegraphs, revolution indicators, helm angle indicator, electric steering telegraph, voice-tube panel, cut-out switchboard, interior communication switchboard (controlling the supply of all circuits for these systems), telephone switchboard, telephone transfer switchboard, general alarm gong contact maker, and warning signal contact maker. Two dynamotors for the energy necessary for the general systems of interior communication are a part of this equipment, but due to their noisy character are debarred from the silent communion with their fellows. This control station is lined on all sides with soundproofing material, that there may be no interruptions to the service occasioned by the ship machinery. The motor generators for the supply of proper voltages, with alternating and direct current to the telephone system, are located without the central station for the same reasons. The dynamotors for the general communicating circuits are wound to transform the standard voltage of 125 volts into three voltages, 6.6, 13.3 and 19.9 volts. Motor generators in duplicate for the telephone system consist of a motor wound for 125 volts; a direct current generator transforming to a normal voltage of 16 with rheostatic control from 12 to 20 volts, mounted on the same shaft, and an alternating current generator producing 80 volts at 16 cycles, mounted on the same bed plate. These motor generators are controlled by the telephone transfer switchboard and the dynamotors are controlled by the interior communication switchboard. This latter switchboard is interesting for the amount of control it provides crowded in so small an area. It is furnished with many sets of bus-bars to accommodate the differences in potential characteristics of the various systems. It supplies 125, 6.6, 13.3, 19.9

volt bus-bars as well as a special set of bus-bars for the batteries which are connected to supply 6.6, 13.3 and 19.9 volts. Adjacent to the central station and made sound proof in like manner are found the sub-stations for fire-control. The two sub-stations permit of duplicate operation of the fire-control, that is to say, that the control of all the turret guns can be accomplished from one sub-station or divided between them. Sub-stations are provided to agree with the number of batteries. A change is now contemplated in this arrangement of compartments whereby there will be secured a further structural division, allowing a special compartment to interior communication apparatus. This arrangement will separate and make distinct the steering compartment, the communicating or central station and that reserved especially for the control of the gunfire.

Although briefly described the extensiveness of these systems goes far to prove their importance and necessity. Embracing as they do every possible need of the navigator, the engineer, the gunner, the passenger and the crew they metaphorically typify the human nervous system with all its sensitiveness and delicacy. As the human is debilitated by some injury or shock to his nerves, in like manner does the vessel suffer from an interruption to its interior signals. Following this simile to even a greater degree, man has ingeniously provided the vessel with means of premonition like unto the intuition or fear of approaching danger which man himself possesses. These advantages have transpired through man's experience, study, and persevering interest in the making of vessels secure in the carriage of human life and cargo. Not one iota should be spared from the praise of man's achievement as shown in the advantages to the English-speaking races of the two transatlantic fast mail steamers "Lusitania" and "Mauretania." In diminishing the time of travel between our shores and that of the Fatherland they have advanced the nadir of world civilization.

No attempt has been made to discuss in this paper any practice other than that of our own country. A comparison of the practice of other nations would be interesting, but would extend beyond the prescribed intention of this treatment. It is obvious to those who are well acquainted with American characteristics that in all paths that lead to progress and advancement in science, art, and civilization our countrymen will be found in the vanguard.

FRANKLIN INSTITUTE

EARTHQUAKES IN THE LIGHT OF THE NEW SEISMOLOGY.

BY

PROFESSOR OSCAR C. S. CARTER.

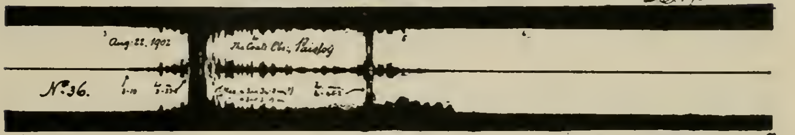
Seismology is a comparatively new science; it was not until about fifty years ago that we began to study it scientifically. Alexis Perrey, a Frenchman, devoted his lifetime to the study of earthquakes, and from 1844 to 1871 compiled a comprehensive earthquake catalogue for the entire globe. This was issued in parts, and is a mine of information which has been drawn upon by workers in the subject ever since. Perrey recorded about 18,000 earthquakes in thirty years. Mr. Mallet, of Dublin, in his report on the Neapolitan earthquake which took place in 1857, was among the first to introduce true scientific method in the study. He introduced new methods of observation and took the subject from the realms of speculation, where it had previously been, and showed that it could be studied in a scientific way.

It can be seen from an inspection of Perrey's catalogue that a neglect of the study of seismology was surely not due to a want of material. It has been truly said that not an hour of the day passes but that an earthquake takes place in some part of the earth's crust. The neglect of the study of seismology may be due to the difficulty and obscurity of the subject, and the fact that man's first impulse is his safety, and he is not in a frame of mind conducive to scientific observation when this observation would be of value. The astronomer in his observatory has the heavenly bodies under his inspection night after night, so that he has named and even classified the mountains and volcanoes of the moon. The chemist can analyze in his laboratory complex compounds, minerals and rocks. The physicist can make his delicate measurements of objects he has before him. The geologist, however, when he studies earthquakes, has to deal with something very fleeting, which is generally studied by its after effects. The shock may start in a far-distant country, 3000 miles

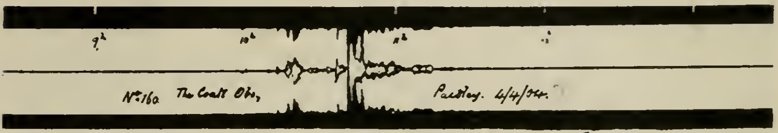
The Coats Observatory, Paisley.

Notable Earthquakes recorded by the Milne Seismograph.

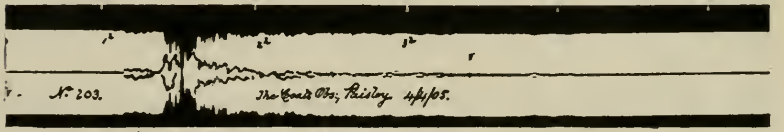
D.C. 1905



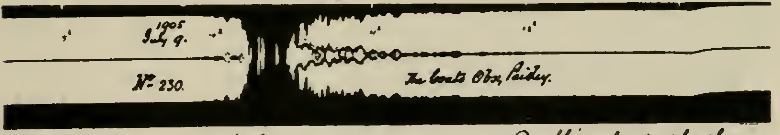
N° 36. Centre near Kashgar, Asia. Five weeks before report reached India. Not sensible in India.



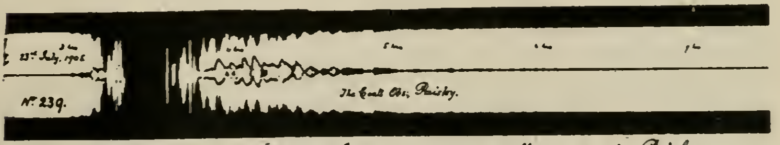
N° 160. Salonika, Turkey. Copy of record sent, by request, to Prof. Pernter, Vienna.



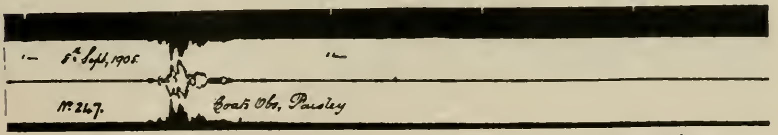
N° 203. The Indian Earthquake. Centre near Kashmir.



N° 230. Supposed origin near Kashgar. No definite news received. Possibly confused with others.



N° 239. Irkutsk, South Central Siberia. Greatest intensity of all recorded in Paisley.



N° 247. The Italian Earthquake. Another of great severity, same region, a week later.

From originals furnished by Prof. John Milne, Shide, Isle of Wight.

or more from the observatory, and, even were the observer present on the ground, the origin or centrum of the shock may often be hidden from view, some times several miles below the surface. The wonder is not that so little but that so much has been accomplished.

Probably the foremost living authority on seismic phenomena is John Milne, whose earthquake observatory is now at Shide, on the Isle of Wight. He made a practical and scientific study of earthquakes for Japan while a resident in the employ of the government.

The subject of earthquakes cannot be understood without a full discussion of the various theories or hypotheses regarding the interior of the earth, that is, the earth below the crust. As has been well said by a prominent geologist, "Many like to have a theory on which they can rely implicitly and regard as final; they dislike to sum up evidence, and suspend judgment until sufficient evidence is collected. This is a habit of mind which should be discouraged, for it deludes one into the belief that he knows the subject when he has only acquired some one's opinions and dogmas, and renders further progress exceedingly difficult to him. In no science are there more open questions than in geology, in none are changes of view more frequent, and in none, consequently, is it more important to emphasize the distinction between fact and inference, between observation and hypothesis. An open-minded hospitality for new facts is essential to intellectual advance." His statement is correct, and shows clearly the attitude the investigator should assume.

When we discuss the different theories about the condition of the earth below the surface we should remember that the study of the interior is at best a very obscure subject, being hidden from our view. The greatest boring has penetrated a little over a mile, the deepest boring being at Schladebach, Germany, about 6000 feet deep. The deepest cañon is the Grand Cañon of the Colorado River, in Arizona, a little over 6000 feet deep in the deepest part. The deepest mine in the United States is the Tamarack, in the Lake Superior copper region, where a vertical shaft was sunk a mile deep. The deepest artesian well is less than a mile in depth. It is seen from these statements that the crust has been penetrated but slightly. Some idea of the interior may be obtained from the deep-seated lavas that come to the surface. Notwithstanding the obscurity of the subject, facts are accumulating year by year, so that it is now fairly certain which view is correct, or at least which views can be discarded.

Most of the theories about the earth can be found in "History of Geology and Paleontology" by Karl Von Zittel, and in our standard geologies, and are presented in the order in which they have been taught.

FIRST THEORY.

The first theory about the earth, and the oldest one, which is being rapidly discarded, is that the earth has a thin crust, below which is an interior of melted rock or lava. This is known as the thin crust theory, because it supposes a crust of from 20 to 30 miles thickness. As the diameter of the earth is about 8000 miles, this would make a very thin crust.

Astronomers and physicists objected to this view saying the earth behaved like a solid rigid body in space and not like a molten mass. They also pointed out that the moon exerts an attractive force on the earth and waters that cover the earth, and in Mid-Pacific a tidal wave from three to four feet high is raised, which seeks to follow the moon in its revolution. If the earth had a crust but 20 miles thick, which in its early history was much thinner, the attractive forces of the sun and moon would have buckled up its surface in the form of land waves. "It is said that Lord Kelvin demonstrated mathematically that a crust or shell of solid steel 500 kilometers (312 miles) thick would yield under the enormous pull of the sun and moon as if it were India rubber." If this is correct, it is evident that if the earth had a crust but 20 miles thick and a molten interior, the combined pull of the sun and moon would buckle up the crust in land waves, and this would take place if the crust were many miles thicker.

SECOND THEORY.

The second theory is that the earth is solid throughout and rigid as a ball of steel. This theory is held by some astronomers and physicists, who object to the thin crust theory and hold that the earth behaves as a solid body in space. This theory harmonizes with the fact that earthquake shocks or waves are transmitted from the antipodes through the solid elastic interior of the earth. This interesting fact was proved by Milne and others and will be explained more fully later on.

It is said the second theory was held by Lord Kelvin. Volcanoes, hot springs, and other thermal phenomena are not so readily explained by this theory as by the succeeding theories. According to this view, if the earth were ever in a molten condition it has cooled sufficiently to become solid.

THIRD THEORY.

The third theory is that the earth is practically solid, but beneath the crust are vast areas or patches of molten rock. In other words, there is a fused layer between the crust and the solid interior. This view was supposed to meet the objections of the astronomer and explain for the geologist the phenomena of volcanoes, but earthquake waves could never travel from the antipodes through the solid interior, and pass through two fused layers of rock on opposite sides of the earth. The waves would be destroyed. They require an elastic medium for their passage. When this theory was first advanced geologists used it to explain the fact that a girdle or belt of volcanoes encircles the earth. Beginning with Kamchatka on the north, Japan, Philippines, Borneo, Java, Sumatra, Antarctic regions, Australia, New Zealand, are volcanic. The islands off the west coast of Africa, Canaries, Cape Verde, St. Helena, etc., are volcanic. Iceland to the north is volcanic. Beginning with Terra del Fuego on the south, the entire western coast of South America is volcanic; so is Central America, Mexico, California, Oregon, Washington, Alaska, Aleutian Islands, back to the starting point Kamchatka. This is only a partial list, as there are other belts or lines of volcanoes.

FOURTH THEORY.

The fourth theory is probably the correct one, and is that the earth is solid on account of the enormous pressure of the rocks. It is hot enough below the surface to melt rocks, but on account of the enormous pressure the material is pressed solid. Whenever an enormous fissure is formed reaching to great depths, the pressure is relieved, the rock becomes molten and the lava reaches the surface, forming a volcano. In the geological past fissure flows over the surface were formed. Earthquake waves transmitted through the earth below the crust can be explained by this view, because, notwithstanding the great heat of the rocks, they are solid and elastic and will transmit waves.

In connection with this fourth theory it may be well to quote Milne to make clear why the metals and rocks are not molten or even gaseous on account of the intense heat in the interior of the earth. Milne states: "At a depth of 200 miles the pressure would amount to about 600 tons to the square inch, probably enough to squeeze the molten rock and metal back into a solid state. At any rate a depth must soon be reached where the pressure is great enough to effect that result.

"You know the general law that heat expands and cold contracts. Well, there are strong reasons for believing that most metals and rocks can be prevented from melting under heat, if you prevent them from expanding. Or if you have a quantity of molten metal, which has already expanded in melting, you can bring it back to the solid state by great pressure, just as you can solidify liquid air by putting it under great pressure.

"The interior of the earth, though potentially liquid, is actually solid and extremely dense. It would immediately become liquid if the pressure were removed. It is hot enough to become liquid, but by the laws of matter cannot do so without expanding, and it cannot expand so long as it is squeezed down under the great weight upon it.

"You must understand that the earth, originally liquid, became solid under two influences. It began to solidify at the surface by cooling, the crust growing thicker and thicker, and it began to solidify at the centre by pressure, the core growing larger and larger. This double phenomenon of solidifying continued until a solid outer shell and a solid inner core came closer together in what may be called the critical region of the earth, a region that feeds lava to volcanoes."

HEATED INTERIOR OF THE EARTH.

Observations made in deep mines and artesian wells show that it gets about one degree hotter for about every 50 feet of descent. This increase is not regular, probably because different rocks conduct heat differently. In England the increase is one degree for 30 feet and one degree hotter for 90 feet, but all over the globe where observations have been made the average is about one degree hotter for about 50 feet.

There is one remarkable exception to this rule in the deep copper mines near Lake Superior, where the increase is but one degree hotter for about 200 feet. Probably the ice-cold waters of Lake Superior, which are near the mine, conduct the heat away from the mines. These waters are too cold for bathing in summer.

According to the average law of increase, the rise in temperature is: 1 degree for 50 feet; 100 degrees for 5000 feet or about 1 mile (5280 feet); 3000 degrees for 30 miles.

On the surface at much less temperature than 3000 degrees silver, copper, and wrought iron can be poured from a ladle, gold vaporizes, and platinum melts. A piece of granite melts and can be poured from a ladle like so much molten glass. But under a pressure of 30 miles of rock the fusing point would rise and it would require a higher temperature to melt granite.

The views of Prof. Milne, the noted seismologist, about the increase of temperature seem to be sound. He says we do not know much about temperatures of over 3000 degrees, and that all surface rocks would melt there. He also says: " Go down 40 miles and you get a temperature of 4000 degrees; at 50 miles a temperature of 5000 degrees and so on until at a depth of 1000 miles you get a temperature of 100,000 degrees, which is absurd. It is a generally accepted view that the earth's temperature increases more and more slowly as you go deeper and deeper, and after a certain point, say 200 miles, the rate of increase is hardly appreciable." The reason this calculation cannot be carried on indefinitely is clearly evident. The figures indicating the temperature become so large that, as Milne states, they are absurd. Even the temperature of the sun, the source of light and heat, is much lower according to Prof. Todd, who says in his astronomy: " The temperature of the sun is very difficult to ascertain. Widely different estimates have been made. Probably 16,000 to 18,000 degrees Fahrenheit is near the truth. But no artificial heat exceeds 4000 degrees Fahrenheit."

According to Moissau and Violle, who made such interesting and important experiments with the electric furnace, 6300 degrees Fahrenheit is the maximum temperature reached in the electric furnace, while others estimate the temperature to be as high as 8000 Fahrenheit. As a matter of fact we know nothing about such high temperatures estimated for the sun, and have no instruments to measure them, and when the estimates become so high they are more or less conjectural.

ELEVATION AND SUBSIDENCE.

Inasmuch as probably 95 per cent. of earthquakes are caused by faulting, that is, by breaking or caving in of the earth's strata, or by the slipping or sliding of the walls of a fissure after the fault has been formed, it becomes necessary to discuss briefly the subject of elevation and subsidence.

The crust of the earth is in a state of unstable equilibrium; parts of the country are rising and parts are sinking. This oscillation or change of level goes on, as a rule, very slowly, perhaps, like a mountain, building only a foot or two in a century, but sometimes it is paroxysmal. For example, in 1835, after a severe earthquake on the western coast of South America, it was found that the whole coast line of Chili and Patagonia was raised from 2 to 10 feet above sea level. The coast line of New Jersey is slowly sinking. According to former State Geologist Cook, the rate is from 2 to 3 feet in a century. This is undoubtedly correct. Old corduroy roads made of cedar trees are found submerged, and in some cases submerged stumps of trees also prove it.

The layman must distinguish, however, between land lost by slow subsidence and land lost by wave erosion and currents. The latter is much more rapid. For example, the land lost between Atlantic City, or better between Chelsea and Longport, is mainly due to wave and current erosion. A subsidence of two feet in a century in the vicinity of the sand dunes would have but little effect.

When the Coast Survey made soundings a few years ago over the submerged coastal plain in order to get the depth in fathoms out to the edge of the submerged continental platform, a distance of from 75 to 100 miles, they found beyond the mouth of the Hudson a submerged cañon which extended for many miles across the submerged coastal plain to the edge of the submerged continental platform. This cañon was said to be in some places nearly 2000 feet deep. As a matter of fact the maximum depth was 2400 feet. Through this cañon the Hudson River once flowed. The cañon undoubtedly shows subsidence.

Submerged cypress stumps off the coast of Carolinas and Georgia show subsidence. Off the coast of Maine are 365 islands and enough harbors and deep enough waters to float all the navies of the world. These islands are simply drowned hills.

When the coast line sank, the hills became partially submerged and the valleys entirely drowned. The deep water is where the valleys are. The rock on the island is of the same kind as that on the mainland.

The Gulf of Mexico, near the region of the delta, is an area of subsidence. The Missouri, which is really the Mississippi, rises in Montana. There is no good reason for taking the smaller tributary, which rises in Minnesota, as the main stream, because it flows due south. The Hydrographic Survey name the Missouri, which is the trunk stream, the Mississippi. This noble river brings to the Gulf of Mexico the wear and tear by erosion of the greater part of the North American Continent. Great slices of prairie soil 20 to 30 feet in thickness are carved off, so that it is well named the Muddy River. When we consider the millions of tons of sediment dumped into the gulf we wonder that it has not filled up long ago. Were it not for subsidence this sediment could never be accommodated.

When artesian wells are put down at New Orleans and in the delta region buried forests are found 200 feet below the surface with the trees standing upright. A popular resort or pleasure island once in the river below New Orleans has disappeared by subsidence.

The California coast is rising. The Coast Range of Mountains whose foot hills come down to the water's edge are still growing. The growth of mountains is very slow, perhaps a foot or two in a century. It is this elevation and faulting, and also the slipping of the walls of various faults, that make California an earthquake country. If the California coast were sinking there would be plenty of good harbors, because the ocean waters would come up the valleys of the Coast Range. As it is there is only one good harbor in California, and that is where the Coast Range of Mountains is dissected by the Golden Gate.

In Miocene times there was a land connection 60 miles wide betwen Alaska and Siberia. This is known as the Miocene Bridge. In those times the camel and the horse, both of which were natives of this country, and afterwards became extinct, roamed at will from Alaska to Siberia. The climate was then mild, and perhaps early man, who is a newcomer on this continent, came over from Asia. Be this as it may, the Miocene Bridge subsided long ago, but the Coast Survey that made us more familiar with the submarine levels and contours of that region than we are with the interior parts of Alaska, tell us that the water is very shallow there.

The crust under the ocean is cracking and caving in, and the line of active volcanoes that marks the nearby region is very significant. Occasionally a new volcanic island pushes its head above the water. Earthquakes along the coast are frequent and severe. As before stated it is elevation and subsidence, causing faults, slipping, and rearrangement of the strata, that produce earthquakes.

The following table by Kayser from "An Introduction to Geology," by Scott, shows elevation and subsidence in different parts of the Globe.

NORTH AMERICA.

Rising	Sinking.
East coast of Greenland.	West coast of Greenland.
East coast of North America to 45° north latitude, Nova Scotia.	East coast of North America from Maine to end of Florida.
Part of Gulf of Mexico and Antilles.	East coast of Central America.
Pacific coast.	
SOUTH AMERICA.	
Pacific coast except that of Peru.	Coast of Peru.
Atlantic coast from mouth of La Plata to 20° south latitude.	Atlantic coast except Uruguay and South Brazil.
ASIA.	
Entire north coast and east coast to 30° north latitude.	East coast of southern China and Tonkin.
South coast and Malay Archipelago.	Laccadive and Maldive Islands.
Asia Minor.	
EUROPE.	
Peloponnesus, Sicily, Sardinia, Ligurian coast, Balearic Islands, south coast of Spain, west coast of France, Ireland, Scotland, Scandinavia.	England, north coast of France, the Netherlands and Germany.
AFRICA.	
East coast of Red Sea, west coast up to Gulf of Guinea.	Atlantic coast of Morocco, east coast of Tripoli, north coast of Egypt, Gulf of Guinea.

WHY SO FEW GEOLOGISTS STUDY EARTHQUAKES

In a signed article in the New York *Evening Post* Prof. T. A. Jaggar, Jr., of the Massachusetts Institute of Technology, is made to say: "A great convention of American geologists has just completed its deliberations in Baltimore (Dec., 1908). All of these gentlemen are interested in earthquakes, but there are probably not more than half a dozen members of the society who have any technical or mathematical knowledge of them, and not many more who have ever experienced one. The idea that such experience was important for a geologist would be scouted as a jest."

The writer was inclined to take exception to Prof. Jaggar's statement and regard it as somewhat exaggerated, but after having read almost an entire page in one of our great dailies, after the Messina earthquake, devoted to the opinions of two geologists of prominence, one of whom is particularly capable, he came to the conclusion that there was considerable truth in Prof. Jaggar's statement. One of these gentlemen had evidently not looked up the subject since he had conned his college text-book. Then, in a more or less satirical vein, the Professor goes on to say:

> Many of these men are teachers in universities. If a Martian astronomer were to appear suddenly in their midst, after returning from a visit to the Lowell Observatory at Flagstaff, where his own existence had been so wonderfully interpreted, the following dialogue might be expected:
>
> "Where you know the heavens so well, of course your own earth is to you as an open book?"
>
> "Yes," reluctantly.
>
> "You have observatories for the recording of all earth phenomena."
>
> "No."
>
> "What! Did you not learn anything about local terrestrial motions before you studied the stars?"
>
> "No, we do not know anything about terrestrial movements."
>
> "Do you mean to tell me that you have not many instruments for observing them?"
>
> "We have the seismograph, but none of us understand it, and as for other earth motions, all we know we have learned from the physicist and the astronomer."
>
> "But you live on the earth, and must have to meet every crisis as it arises: can you foretell nothing?"
>
> "Well, you see, we don't think of it that way. We treat it historically, and make notes, and use a hammer and a compass, and are very much interested in the bones of Jurassic reptiles and in making maps of the rocks, and in finding out all about iron and coal. But we have no such precise knowledge as the astronomer."
>
> "But surely, in teaching your young men in the universities, you begin by precise instrumental study of the present earth and its processes, and have a vast accumulation of experience concerning those processes, in the form of tables, measurements, formulæ, curves, diagrams and computations?"
>
> "No, almost nothing has been done in accumulating experience or empirical data, except by the Japanese. When a volcanic eruption or an earthquake occurs we send a geologist to study the results, and he writes a thick and learned report. We do not know anything about what the conditions were during the months before the disaster. We teach our young geologists

first a little physics and chemistry, and a few generalities about earth process, and then set them to work mapping ancient rocks. The highest development of geology is the unraveling of the history of the past. We haven't time to go into prediction and humanistic geology."

THE SCIENCE OF GEONOMY.

The above is not exaggerated. The blame does not rest with the geologist; it rest rather with the haphazard growth of the science, and the proximity of the earth has made terrestrial observation and measurement difficult, in view of the littleness of man. This plea, however, can no longer be urged in extenuation of the neglect of the study of earth process. We have a considerable knowledge of physical science, and there are many instruments applicable to the earth. There is a very precise science known as geodesy, which has for its object the determination of the figure of the earth. There is geology, which aims to decipher earth history. Between these two there is needed a new science, many phases of which are now being studied, and this might well be named geonomy, the science of the laws which govern the earth.

There is one grave difficulty in the way of rapid development of this science, and that is expense. It is a science that calls for the establishment of observatories in many lands. These observatories will have for their objects the study of the changes which are going on in the crust of the earth under them and the relations of those changes to astronomical and meteorological changes. The new science, like astronomy and the study of the atmosphere, deals with moving things and so requires continuous local records, through weeks and months and years. Seismographs, microphones, magnetographs, gravity pendulums, pyrometers, tromometers, gas-collecting apparatus, and many special instruments adapted to local needs are among the devices with which an earth observatory should be equipped.

The natural places for establishing such observatories at first are lands where the earth movements are most rapid, regions of volcanoes and frequent earthquakes. The Japanese have taken the lead in such establishment, and their island empire is girdled with observatories. The writer has before him a pamphlet, in English, printed in Tokio in October, 1908, containing eleven contributions to practical seismology by a Japanese investigator, F. Omori, the first of which bears the significant title "On the Fore-Shocks of Earthquakes." Dr. Omori declares, "My belief is that a large destructive earthquake will be foretold in its epicentral region by some fore-shocks," and he substantiates his belief by exact instrumental proofs.

SICILIAN DISASTER PREDICTED.

With reference to Sicily, it is well to make note of the fact that an American volcanologist, Frank Alvord Perret, has predicted disaster on Mount Etna for two years past. Mr. Perret, who was decorated by the Crown of Italy for his splendid service to science and to humanity on Vesuvius in 1906, wrote in the World's Work of November, 1907: "By the rational methods of scientific research, we know that a great eruption of Mt. Etna is impending, the only uncertainty at present being which side of the mountain will break open." Great volcanic eruptions are preceded by great earthquakes, and the Messina disaster of December 28 comes on an earthquake date ("terrestrial maximum of gravitational stress") actually platted in advance by Mr. Perret on his diagrams for 1908. Like Dr. Omori, he is a man whose whole time is unselfishly devoted to these studies, but he has no observatory and no adequate means of support. A few business men in Springfield, Mass., last year came valiantly to his aid, and now their foresight is worthy of all honor. When young men think of making science their life-work, it would be well to remember Pasteur, and to consider carefully whether the "highest" development of the investigative faculties may not concern itself with humane rather than with historical motives. To those who will give time and money to the establishing of earth observatories there will come, by way of reward, some of the most astonishing discoveries of the twentieth century.

Prof. Jaggar is especially interested in earthquakes and volcanoes, and has done excellent work in the latter subject.

Suppose for the sake of argument many of the younger geologists should begin the special study of seismology. They would have to take up their abode in some earthquake country like Italy or Japan, because this is not an earthquake country in the sense that Japan is. Severe earthquakes in this country are generally separated by long intervals of time. Of course there are exceptions. The specialist in seismology in this country would find himself more or less handicapped for want of local material and proper instruments. It would be like locating a college in the prairie country, where no rocks are exposed, and telling the students of geology to become proficient in stratigraphy, or telling the students who live along the gulf coastal plain to become experts in glacial geology. Environment is often a determining factor in deciding what investigations a man shall pursue in geology. At all events a man would have to be well equipped in the recent discoveries in modern seismology before he could make observations anywhere. What is undoubtedly needed are earthquake observatories at proper intervals over the country, and observers who are able to interpret the readings of the seismograph skilfully.

There are only about five seismographs in the United States, while Japan is girdled with observatories. There is one at the Weather Bureau Station at Washington, one at Johns Hopkins University, Baltimore, one at Harvard University, one at the Yerkes Observatory, Wisconsin, and one in California. Every large college and university should have a seismograph. The use of a seismograph was strikingly shown in Australia. Two breaks occurred in the cable, one in 1880, the other in 1888. The inhabitants were shut off from communication with the mother country, England, and the rest of the world. They were in a state of uncertainty and dread, not knowing whether war had been declared or whether some hostile foe had cut the cables. The troops were called out and put in readiness and nineteen days elapsed before a word came. A seismograph at the capital would have soon reassured them and shown that the break was due to a submarine earthquake.

PROF. JOHN MILNE AND HIS DISCOVERIES.

Milne is the foremost seismologist to-day, and received his education at King's College, London, and the School of Mines. He was employed by Cyrus Field, of cable fame, soon after his graduation to report on some coal fields in Newfoundland. His next offer was from Japan, which country was then securing the best foreign talent available to exploit her mineral resources. Japan probably offers a better field for the seismologist than any other country, and Milne's attention was soon directed to the study of seismic phenomena for the Japanese. He taught them how to build their houses and bridges earthquake proof as far as possible. He devised a number of seismographs, some simple in construction, others more intricate and exceedingly delicate.

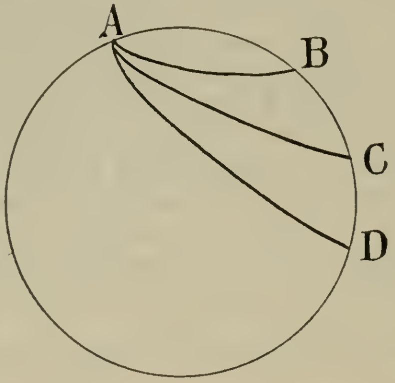
Japan appreciated his studies and results and placed him in the chair of seismology at the university. Some of Milne's preliminary experiments were made by drilling holes of various depths in the solid rock and exploding dynamite. The emperor took a keen interest in the experiments to determine the velocity and direction of the wave motion, and often himself exploded the charge with an electric button. Milne spent twenty years in the study of earthquakes in Japan, and finally returned to England, where his observatory for the study of seismology is located at Shide, on the Isle of Wight.

There is one very important fact that Milne proved several years ago, namely,

DISTANT EARTHQUAKE WAVES TRAVEL STRAIGHT THROUGH THE SOLID ELASTIC EARTH BELOW THE CRUST.

This is probably the most important discovery made in recent years in seismology, and one which the general public and some of the writers of text-books have not grasped as yet. It is doubly important from the fact that, notwithstanding that the study of the different theories about the earth and its interior is a very obscure one, this proof of Milne's helps us to eliminate and discard the thin crust and molten interior view, and also the theory of a solid crust and solid interior with a pasty or viscous layer sandwiched between.

It is very evident that an earthquake wave requires a solid and elastic medium for its propagation, and it could not travel from Japan to England below the crust through a molten mass, which is not, of course, solid or elastic. And it is also very evident that if we consider the pasty layer view in reference to this proof of Milne's, it will not hold, because the earthquake wave would have to pass through two pasty layers before reaching England, neither of which is elastic or suitable for the propagation of earthquake waves. Now what proof has Milne that the earthquake wave travels through the solid earth first and not around the crust? Namely, this: He says, for example, if an earthquake wave were to travel from Japan to England through the crust around the circumference, we would get two messages—the one traveling through the shortest arc of the circumference we would get first and the one coming the longest distance we would get last, because the waves would travel in both directions. Now as a matter of fact we only get one message through the solid earth, traveling along the chord of an arc.

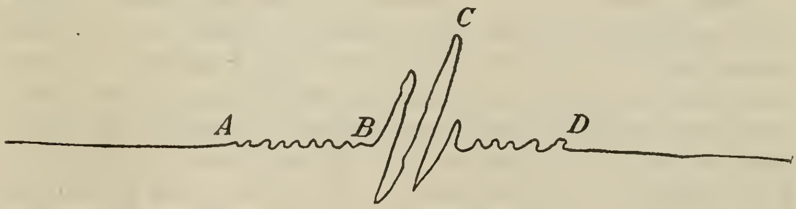


We are indebted to articles by Milne, and also to an excellent interview by Cleveland Moffett with Milne, for the interesting and popular way in which some of these facts are set forth. For example: If an earthquake starts at A, it will travel through the solid earth first from A to D along the chord AD, also from A to C and A to B. The other and later waves travel along the surface from A B C to D a considerable time afterward. It travels through the solid elastic interior much more rapidly than it does through the fissured crust. All the waves from far-distant earthquakes reach the Isle of Wight in practically the same time. They travel from Japan, Borneo, and Java to England in about 16 minutes.

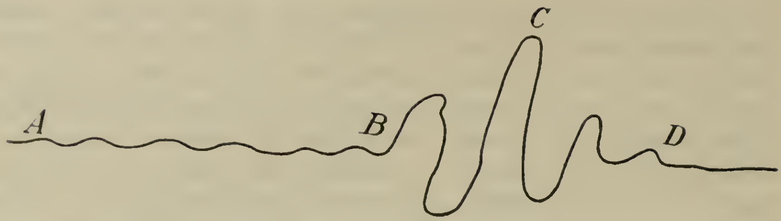
Milne says that an earthquake wave from Borneo reaches England in nearly the same time that one from the West Indies does, and Borneo is nearly 2000 miles farther away. This he says is due to the fact that the wave from Borneo travels through the earth at a much greater depth than the wave from the West Indies, and consequently it travels much faster, because the earth at a greater depth is much more elastic and rigid. Earthquake waves that start on the opposite side of the globe travel much more quickly than those that start on our side of the globe because they travel deeper through the more rigid elastic interior. In fact the shock of a nearby earthquake may reach us through the crust. Moffett asked Milne a leading question when he said: "If all the earthquake waves on the opposite side of the globe reach England in practically the same time, how do you know in what place or country the earthquake started?"

CAN THE SEISMOGRAPH INDICATE IN WHAT COUNTRY THE EARTHQUAKE STARTS?

Milne stated we recognize waves that start from different countries, Japan, Borneo, India, South America, and other countries by their signatures or seismograms recorded by the seismograph. For example, an earthquake wave that has traveled 3000 miles makes a different signature on the photographic paper or smoked paper of the seismograph from a wave that has traveled 5000 miles. One that has traveled 7000 miles makes still another record. The different signatures are due to the distance traveled: For example, below is a message recorded by an earthquake that has traveled a shorter distance than 3000 kilometers.



After the same wave has traveled 9000 kilometers, the wave would record at another station a message or seismogram somewhat like this



If the wave traveled a longer distance the message would be stretched out still more.

When a great earthquake takes place on the other side of the globe, the first waves to reach the observer on the Isle of Wight or any other far-distant station are the so-called first preliminary tremors recorded by the seismograph. These are the waves that have traveled through the rigid earth far below the crust. They have taken a short route and traveled along the chord of an arc connecting the place where the earthquake started and the observatory where the seismographs are located. These are the longitudinal or compressive vibrations. The large waves of the main shock travel after these preliminary tremors. These large waves, according to Hobbs, have in the severest earthquakes " a length sometimes of 34 miles and a rise and fall of no less than 20 inches. They appear, therefore, to travel like a slow swell along the earth's surface." In both the above figures the point A, where the line begins to assume a wave-like structure, marks the beginning of the earthquake. The wave-like line A B shows the preliminary tremors which invariably precede heavy shocks. The large waves which produce the heavy shock are shown at C, and D marks where the earthquake tremors slowly become extinct.

Milne states that " it is mostly in these preliminary tremors that earthquakes reveal their identity. These are the rapid waves, but the slower they come the longer it takes to record them, and the more stretched-out they become in the seismogram. And by carefully noting these differences, especially the time it takes to record the tremors and the large waves, we get our information. Now the time it takes to record preliminary tremors by the horizontal pendulum of the seismograph is known for Borneo, Java, Japan, region east of Newfoundland, West Indies, and other places. Hence we can tell how far distant in miles from the observer the earthquake occurred. The time it takes the shock to travel through the earth should not be confused with the time it takes the seismometer to record it.

" Other observatories have similar data. An earthquake, for example, occurred so many miles from the Isle of Wight, a certain number of miles from Batavia, so many miles from Argentina. We can with the help of a pair of compasses on the map fix the place beyond question."

LASKA'S RULES (HOBBS) FOR FIXING THE DISTANCE OF SEAT OF DISTURBANCE IN REMOTE EARTHQUAKES.

" If $V1$ be the time in minutes of the commencement of the preliminary tremors, $V2$ that of the second preliminary tremors, and B that of the main waves in the seismogram; and if Δ be the distance in megameters (1 megameter equals 1000 kilometers or about 621 miles) then

$$1 + \Delta = V2 - V1 \text{ and}$$
$$3\Delta = B - V1.$$

" It has been proved by many determinations that these formulas are correct to a close approximation. They may be stated in simple form as follows:

" (1) The duration of the first preliminary tremors in minutes less one is the distance of the seat of the disturbance in megameters.

" (2) The duration of all the preliminary tremors in minutes is thrice the distance of the seat of the disturbance in megameters."

LOCATION OF A DISTANT EARTHQUAKE FROM THREE STATIONS (HOBBS).

" It is evident that if the distance of an earthquake from the observing station may be accurately determined, its distance from three or more widely separated stations is sufficient to fix its location upon the earth's surface. From two such stations its location is fixed as at one or the other of the points where the arcs described (upon a globe) from each station with radii equal to the distance as determined from these stations, intersect each other. The arc described by the same method from the third station tells which of these intersections corresponds to the locus of the earthquake. A lack of precision in any of the determinations tends to be corrected as arcs are described from a larger number of stations, and the probability of considerable error may be gauged from the size of the so-called triangle of error at the intersections. The simple principle involved in this method will be clear from inspection of the map."

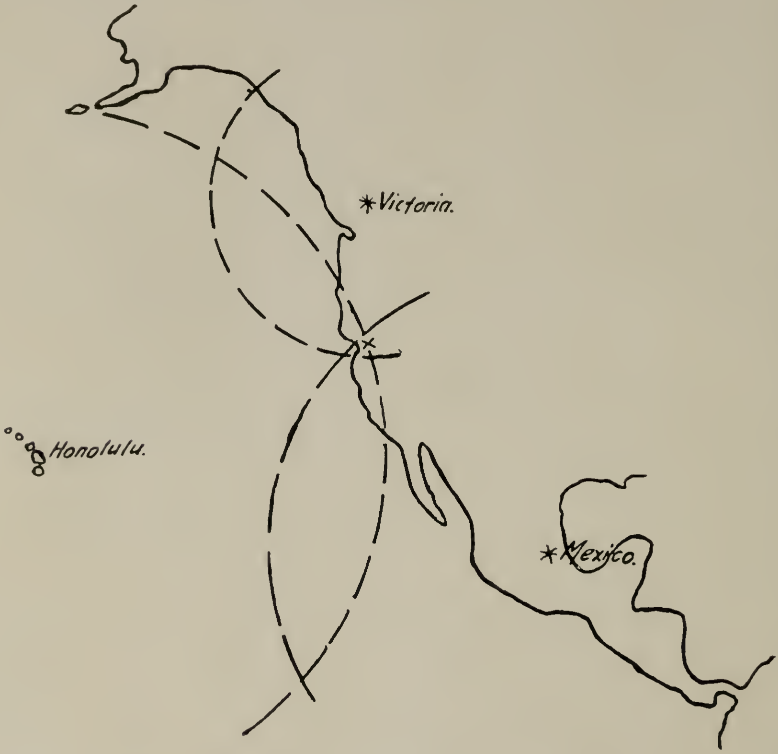


Diagram to illustrate the location of an earthquake from observations made at three widely separated stations —*From Hobbs.*

THE LARGE EARTHQUAKE WAVES.

When a portion of the crust of the earth suddenly caves in, or when a great fissure opens in the crust extending across the country for miles, or when the walls of a fissure already formed and cemented together slide horizontally or vertically, then, besides the waves of compression which travel through the interior of the earth, there are other waves known as the large waves that travel along the earth's surface. They travel like a slow swell, the crust is lifted up in long waves. After these waves have traveled great distances across the continent, Milne has calculated that then they measure from 20 to 40 miles from crest to crest, and their crests or swells rise two or three feet above the level, so that mountain ranges, hills, plains, and entire cities are lifted up a foot or more and settle down again all together so evenly and so very slowly that the observer does not notice it, but the seismographs record it. In this way London, Paris, New York, and Chicago are raised and lowered many times during a year by these waves. It takes from 10 to 20 seconds for these waves to rise, and from 10 to 20 seconds for them to fall according to Milne.

The earth's crust is very elastic and is continually pulsing and quivering with tremors caused by earthquake disturbances that take place on the opposite side of the globe. It rises and falls like the ocean. The ground rises and falls with the smaller of these great waves about three inches, that is, it rises slowly, taking about 15 seconds, and then subsides slowly, taking the same time. In this way an entire city may rise and fall, but so slowly that the observer cannot feel or notice it, but the seismograph records it at once.

The rise and fall of these great waves a foot or more, and so slowly that the observer does not notice it, is the most difficult statement for the layman to believe. Prof. Hobbs, geologist of the University of Michigan, an authority on seismology, makes the same statement in his book, where he says: "The large waves of the great Indian earthquake of 1897 had a complete period of 22 seconds, a length of 34 miles, and a rise and fall of no less than 20 inches. These waves therefore appear to travel like a slow swell along the earth's surface, and they would be felt by individuals save only for the extreme slowness of their motion. The first preliminary tremors from this earthquake had an estimated period of 0.5 to 0.8 of a second and their amplitude was but a fraction of a millimeter.

IS THERE ANY CONNECTION BETWEEN VOLCANOES AND EARTHQUAKES?

It has long been known that volcanic regions are regions of frequent earthquake. This has led many to think that there is an intimate connection or relation between the two. Notwithstanding the fact that earthquakes often accompany volcanic eruptions, and the coincidences are very striking, we have very many instances also of earthquakes occurring in regions far removed from volcanoes, and also in volcanic regions when there is no connection between the two. Milne puts the subject in this way: "The residents of a volcanic country, when seeking for the origin of an earthquake, invariably turn towards the volcanoes which surround them. If a neighboring volcano is in a state of activity, it is often regarded as a safeguard against seismic convulsions. In other cases it is looked upon as the cause of such disturbances. In a few instances both of these views have apparently been corroborated.

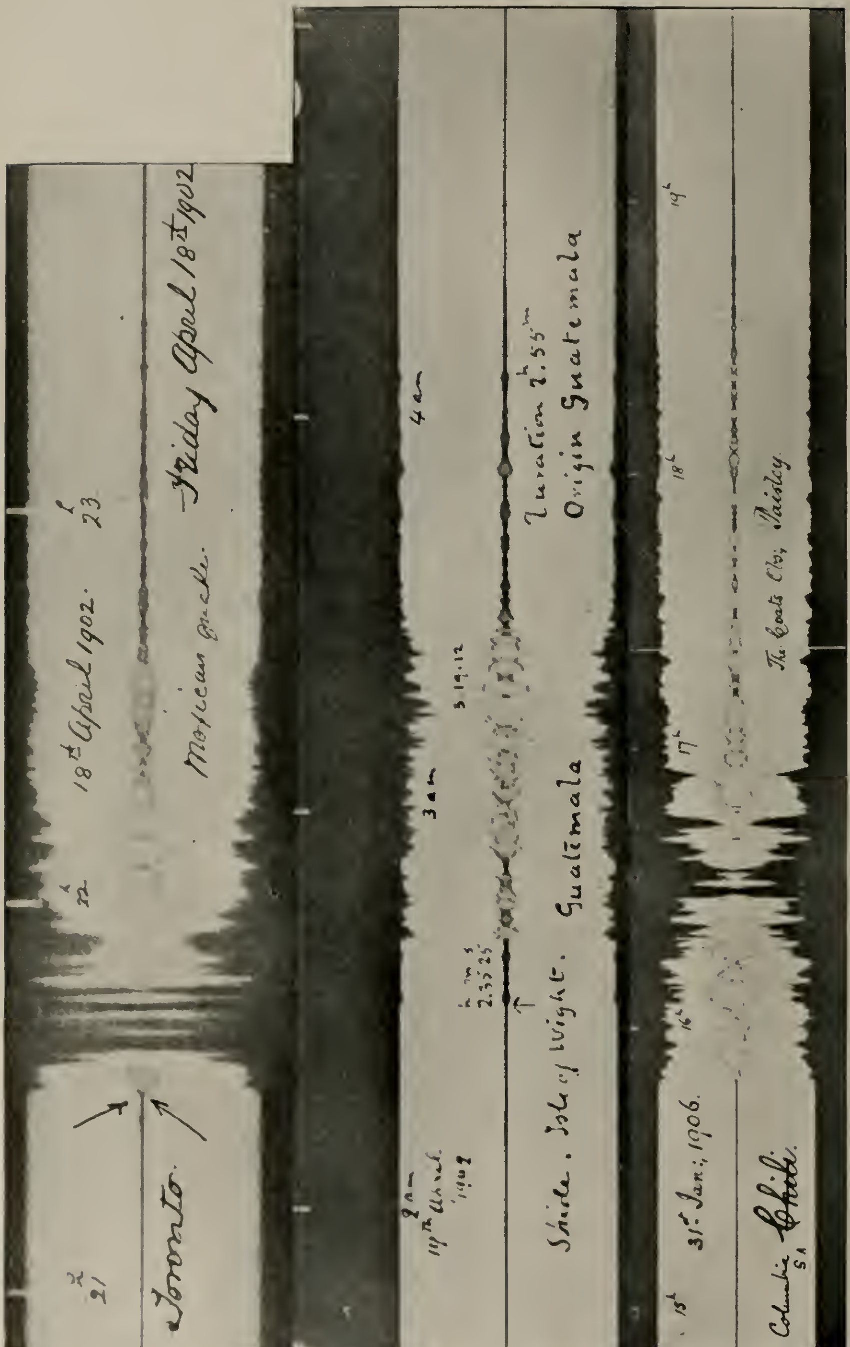
"When we consider that an earthquake and a volcanic eruption may both be the result of some great internal convulsion, and that first the one and then the other may take place in the same neighborhood, it is natural to expect that when these internal forces have expended themselves in the production of one of these phenomena, it is not so likely that they should manifest themselves in the other. The inhabitants of Sicily and Naples, we are told, regard eruptions of Etna and Vesuvius as safeguards against earthquakes. From an examination of the records of the large earthquakes and the volcanic eruptions which have taken place during the last 2000 years, Dr. Naumann found there was often approximate coincidence between the times of the occurrence of these phenomena, suggesting the idea that the efforts which had been sufficient to establish the volcano had at the same time been sufficient to shake the ground. Many of the great earthquakes of South America do not appear to have been connected with volcanic eruptions. The great earthquakes of the world, like those of Calabria and Lisbon, which took place in regions that are not volcanic, have not, as Fuchs tells us, taken place in conjunction with volcanic outbursts. In Japan and in the Sandwich Islands, and in many other parts of the globe, the small earthquakes which occur almost daily do not appear to show any connection whatever with volcanic disturbances."

To Milne's list of the great earthquakes of the world which had no connection with volcanic outbursts may be added the San Francisco earthquake, the Jamaica earthquake, and the Messina or Sicilian earthquake, 1909. Milne then instances examples of the synchronism of earthquakes and volcanic eruptions. One of the earliest was the destruction of Herculaneum and Pompeii by an ash and cinder shower 79 A. D., accompanied by severe earthquake.

At the time of the eruption of Kileau in 1789 the ground shook and rocked so that people could not stand. The first eruption of the volcano Irazu in Costa Rica, in 1783, was accompanied by violent earthquakes. At the time of the great earthquake at Concepcion, in 1835, while the waves were coming in, two great submarine eruptions were observed. In 1797, when Riobamba was destroyed, the neighboring volcanies were not affected, but Mt. Pasto, 120 miles distant, suddenly ceased to throw out its usual column of water. On the night of December 10, 1874, a strong shock was felt in New England, while at 4.45 A.M. on December 11 a shock was felt in the Pic du Midi, in the Pyrennes. In the middle of December there were volcanic outbursts in Iceland. Milne then says, "It is possible that these occurrences might be the results of some widespread disturbance beneath the crust of the earth or perhaps of widely-extended earth pulsations. The probability, however, is that these coincidences are accidental. When we remember that in a small area like the northern half of Japan alone there are periods when at least two shocks per day occur, on the average, it is impossible for these coincidences not to exist. Less frequently coincidences between the larger disturbances must occur. Over and above these accidental coincidences, it would appear that in the world's history there have been periods when earthquakes were unusually frequent, and at such times distant countries have suffered simultaneously. This does not imply an exact synchronism in the single shocks. Small earthquakes or, more properly speaking, local tremblings are a necessary accompaniment of almost all volcanic eruptions. Tremors of this description are seldom, however, felt beyond the crater, or at the most upon the flanks of the mountain where the eruption is going on. They are due to the explosive action of steam bursting through the molten lava."

Besides the illustrations given above by Milne we might mention a most striking coincidence that took place after his book was written, namely, the severe earthquakes in California known as the San Francisco earthquake, and the severe eruption of Vesuvius, which took place at nearly the same time. This gave rise to a widespread discussion at the time by the general reader as to whether there was any possible connection between the two. There is no direct connection, of course, between the two. Between these far distant places we have that profound depression, the Atlantic Ocean, and a continent crowned with massive mountain ranges.

The writer heard a member of the California earthquake com-



From originals furnished by Prof. John Milne, Shide, Isle of Wight.

mittee state in a lecture that the reason for the coincidence was the general seismic condition of the globe. This may be correct, but is rather indefinite, and it is desirable to know what is the cause of the general seismic condition of the globe at any given time of unusual activity in earthquakes or volcanoes.

If we could only believe the theory that the combined pull of the sun and moon when in a favorable position exerts such an enormous attractive force on the earth, parts of which are in a state of fearful stress and strain and ready to break, crack, slip, or slide, and that this attractive force does not produce a break necessarily, but only determines the time when the break occurs, then we could explain the synchronism of earthquakes and volcanoes on different parts of the globe or, better, in different parts of the same country. When the fissure forms or the walls slide, the earthquake shock or wave travels, and the compression and readjustment of the walls of fissures sometimes squeeze out the lava forming volcanoes.

Prof. Perrey, of Dijon, who did so much for seismology and devoted a lifetime to a preparation of a catalogue on earthquakes, held the view that the abundance of earthquakes at certain seasons was due to the attractive force or combined pull of the sun and moon. Rudolf Falb, whose predictions and writings have attracted attention, inclines to this view and endorses Perrey's conclusions. In 1873 he predicted the destructive earthquake of Belluno. In 1874 he predicted the eruption of Etna.

Milne states: " That earthquakes are slightly more numerous at these particular periods than at others is a strong reason for believing that the attractions of the sun and moon enter into the list of causes eventually culminating in these phenomena."

Hobbs seems to think that Perrey's data are negative, because he says: " Perrey wished to find out whether earthquakes stand in any relation to changes in the moon, and while the results of his study, as generally interpreted, furnish a negative answer to his query, the investigation has nevertheless yielded a most important contribution to the science of seismology."

As regards the relation or connection between earthquakes and volcanoes, Hobbs takes the same view as Milne. He says: " It has long been recognized that the earthquake zones of the globe are also the zones of active volcanoes. It cannot be denied that the coincidence is one of great significance, but the relation of one phenomenon on the other is not that which has generally been supposed. In the clearer light of to-day we are able to say that volcanoes and earthquakes alike are due to the action of those forces which have built up the near-lying mountain ranges. To form such mountains it was necessary for great strips of the earth's crust to be pushed up in successive movements between lines of fissures. The jolting movement of the earth blocks as they have slipped over each other accounts for the earthquakes, and the melted rock material, which as a result of the movement has been squeezed out, either along the fissures or, as is more frequently the case, at their intersections, has built up the volcanoes. Wherever mountains are still growing, earthquakes and active volcanoes are to be found. Where they have ceased to grow, there the earth does not shake—it is dead and lava is no longer exuded through the fissures in the surface." While this statement in the main is correct we might find an exception to it in the Charleston earthquake.

EARTHQUAKES AT SEA.

Inasmuch as three-fourths of the surface of the earth is covered with water it is to be expected that submarine earthquakes are very frequent. Not only are they frequent, but they do fearful and appalling damage, as they are responsible for the enormous earthquake waves at sea. A wave of water 20 to 80 feet or more in height advances on the lowlands or rushes up the estuaries, submerging entire villages and sometimes landing large vessels high and dry. An earthquake, the epicentrum of which is often hundreds of miles from shore, is sometimes responsible for the snapping or breaking of submarine cables, and when these breakings are frequent the loss to the companies is enormous.

The topography of the ocean bottom is different from the relief of the dry land. There are submarine mountain chains and submarine volcanoes that rear their crests above the ocean as thousands of islands in the Mid-Pacific and elsewhere. These submarine mountains are not dissected by canyons and ravines like the mountains on the surface, because there are no rivers, rain, frost, and gases of the atmosphere to carry on the work of erosion.

Oceanography, like seismology, is a new science, started since the middle of the nineteenth century. The general outlines of the coast have been known since the time of the early explorers. The exploration of the sea bottom by soundings in deep water was first made in 1840 by Sir John Ross, who was the first to do deep sea dredging.

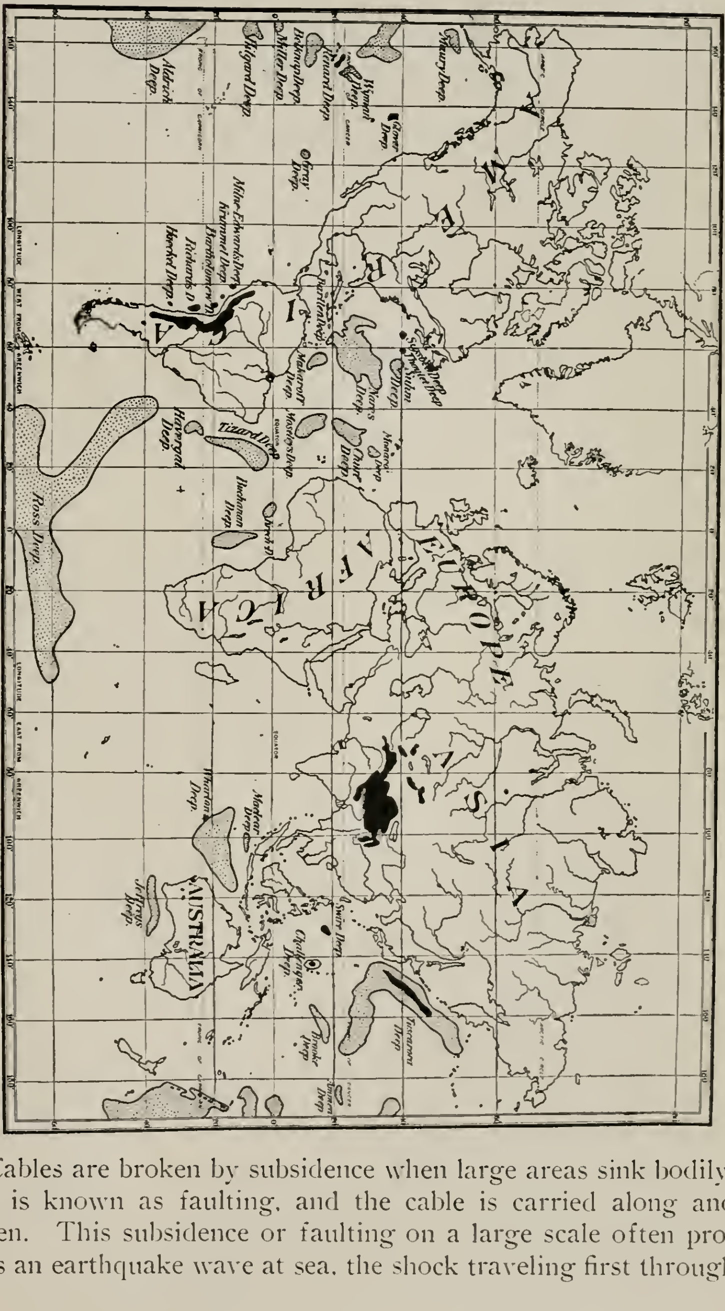
It was not until 1872 that we learned much about the ocean bottom. During that year the Challenger was fitted out by Great Britain to study the ocean bottom and its fauna. Some of the best scientists superintended the work, and for four years she sailed the oceans of both hemispheres, dragging the bottom with nets and dredges and sounding the greatest depths with steel wire carrying an iron weight.

After the return of the Challenger it took nearly twenty years to study and corrollate the immense and varied amount of material and data collected. Leaders in science in different countries helped. Sir Wyville Thompson and Sir John Murray, of England, Haeckel, of Germany, Agassiz, of the United States, Rénard, of Belgium, and others of equal prominence helped to make the fifty royal octavo volumes that make up the history of the sea and its depths. The vessels of other nations have continued the work, and the Blake, of the United States Coast Survey, has done excellent work with others, so that we know more about the coast line and the depths along Alaska, for example, than we know of the interior.

A great portion of the ocean bed is flat, but there are mountain ranges, broad plateaus, great depressions like valleys, very steep slopes or scarps, like those that wall in the great depths, and lastly the steep slopes at the edge of the submerged continental platforms. Cuba and the surrounding islands are the crests of submerged mountain chains. The Pacific is narrow and shallow near Behring Strait, but opens wide farther south. The vast number of islands in the Pacific show that the numerous mountain ridges of which they are the tops trend northwest and southeast. Soundings made by the Challenger and other vessels show abyssal depths in certain parts of the Pacific. The Tuscarora deep, east of Japan, extends from the Philippines to Java, one sounding reached 27,930 feet. The Aldrich deep, northeast of New Zealand, reaches a maximum depth of 30,930 feet. The deepest sounding in the Pacific is 31,614 feet, known as the Challenger deep, sometimes called the Nero deep, south of the

Ladrone Islands, and lacks only 66 feet of being 6 miles in depth. A short distance off the west coast of South America are five widely separated deeps reaching 24,000 feet.

The bottom of the Atlantic is traversed by a ridge running the length of the ocean and dividing it into two great troughs or valleys from 15,000 to 20,000 feet deep. One valley is on the American side of the ocean and the other extends south from the British Isles. The mountain ridge separating these valleys ends in mid-ocean in about the latitude of the Cape of Good Hope, so that a broad basin extends down to the Antarctic regions, where Ross deep is encountered, from 18,000 to 24,000 feet in depth. The greatest sounding in the Atlantic is the Blake deep, near Porto Rico, 27,366 feet. Off the eastern coast of the United States for 75 to 100 miles out the water is shallow, because there lies the submerged coastal plain, and when a vessel is wrecked there the masts stick out of the water, but where this coastal plain ends is the edge of the continental platform, and the ocean goes down abruptly to abyssal depths. In this brief description of the ocean bottom, which is necessary for an understanding of submarine earthquakes, only a few of the great depths are mentioned. An inspection of the rough sketch map after Sir John Murray will show some of the others. These, according to Milne, are the great danger regions of the oceans' beds and enormous sums could be saved the cable companies if we knew their exact boundaries. Whenever we come to a sudden slope or scarp or precipice in the ocean extending abruptly for many fathoms down, we can safely say this is a danger point. He says: "There have been submarine earthquakes like that of June 15, 1896, that have shaken the earth from pole to pole. Cables from Java have been simultaneously broken, and in 1890 three cables to Australia snapped in a moment. The great majority of breaks in the North Atlantic cables have occurred in the deep 300 miles east of Newfoundland, where there are two slopes, one from 708 to 2400 fathoms in a distance of 60 miles, and the other from 275 to 1946 fathoms within 30 miles. On October 4, 1884, three cables lying about 10 miles apart broke simultaneously at this spot. The significance of such breaks is greater when you bear in mind that cables frequently lie uninjured for many years on the great level plains of the ocean bed where seismic disturbances are infrequent."



▨ Representing Sea Depths Exceeding 18000 Feet.

■ Representing Sea Depths Exceeding 24000 Feet and Heights of Mountains Exceeding 12000 Feet.

After Sir John Murray.

Cables are broken by subsidence when large areas sink bodily. This is known as faulting, and the cable is carried along and broken. This subsidence or faulting on a large scale often produces an earthquake wave at sea, the shock traveling first through the solid rock followed by the great sea wave. Cables are broken also when enormous rock masses descend a steep slope. All submarine earthquakes, however, do not produce sea waves.

The connection between this brief statement of the topography of the ocean bottom and submarine earthquakes, and the lessons to be learned are that earthquakes of great intensity are more likely to occur where the steep walled great deeps are located, or where there are steep scarps or abrupt submarine precipices, because by the slipping of the walls of a fault, subsidence, or caving in of the ocean bed is more likely to occur there. These are the great danger spots for cables on account of these phenomena which produce submarine earthquakes.

As before stated, cables laid on even submarine plains, plateaus, or in great valley-like depressions may remain unaffected for years, because subsidence or caving in of the strata which causes the earthquake is more infrequent there. This rule is not invariable, however, because earthquakes may occur anywhere on the ocean floor. Moreover, submarine earthquakes are not always accompanied by the enormous sea waves, neither is the water always agitated on the surface. Vessels receive sharp jolts or jerks, and often a severe shaking, and yet the water is unruffled on the surface. "On February 10, 1716, vessels in the harbor of New Pisco were so violently shaken that both masts and ropes were broken, and yet no motion in the water was observed. Some have described these shocks like those which would be produced by the sudden dropping of large masses of ballast in the hold of the vessel." Milne states: "From the rattling sound which has accompanied some of these submarine shocks, many of which have never been recorded as earthquakes on the neighboring shores, it does not seem improbable that they may have been the result of the sudden condensation of volumes of steam produced by submarine volcanic eruptions. As confirmatory of this supposition we have the fact that many of the marine disturbances, which might be called seaquakes, have been observed in places which are close to or in the line of volcanic vents."

Most of the submarine earthquakes have been recorded on shore. "For example, at the time of every moderately severe earthquake which has shaken Yokohama, the same disturbance has been felt on board the ships in the adjoining harbor. In some cases the effect had been as if the ship was grounding, in others as if a number of sharp jerks were being given to the cable. At the earthquake in St. Thomas, in 1868, it is said that the water receded shortly before the first shock. When it returned after the second shock, it was sufficient to throw the United States ship Mononghela high and dry. Another American ship, the Wateree, was also lost in 1868, being swept a quarter of a mile inland by the sea wave which inundated Arica, The sea waves of 1877 removed it still farther inland. At the time of the Jamaica earthquake, in 1692, the sea drew back for a distance of a mile. On October 28, 1724, Lima was destroyed, and on the evening of that day the sea rose in a wave 80 feet high over Callao. Out of the 23 ships in the harbor, 19 were sunk and 4 others were carried far inland. The first movement which is usually observed is a drawing back of the waters, and this is so well known to precede the inrush of large waves that many of the inhabitants of South America have used it as a timely warning to escape towards the hills, and save themselves." During the Charleston earthquake of 1886 there were hundreds of vessels in the vicinity, but only five felt the shock and these were located in a line with the greatest disturbance on land. A ship, the Nina Mathilde, when 37 miles northeast of Charleston Light, received such a severe shock that the crew were thrown out of bed. This ship was in an unusually favorable position to receive shocks over the line of disturbance.

SEISMOGRAPH.

Seismometers or seismographs, as they are more generally termed, are instruments for detecting or measuring the earthquake shock or wave. Some of the modern ones are extremely delicate and sensitive, so sensitive, in fact, according to Milne, that if the solid column of masonry communicating with the rocky floor be pressed with the hand, the seismograph which rests on the masonry will be affected, and the horizontal boom or pendulum will be set in rapid vibration. If two Milne seismographs provided with horizontal pendulums be put on high buildings opposite each other on one of London's traffic streets when crowded with the heavy drays, they will show that the tops of the buildings bend over slightly towards each other.

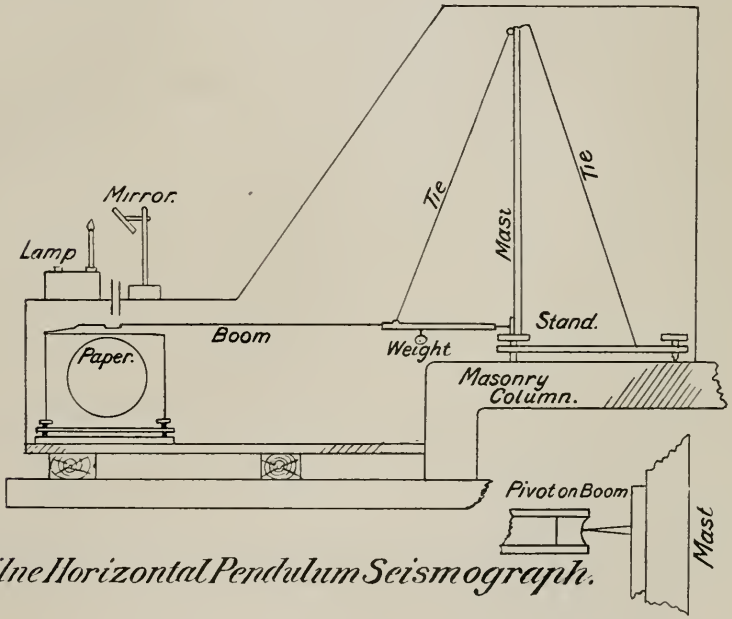
Rude forms of seismographs were in use for indicating the direction from which the shock came long before the most elementary facts about seismology were known. One form long in use and of simple construction was a circular vessel filled to the top with mercury. Around the top was a ring of holes corresponding in position to the points of the compass. During an earthquake shock the vessel was shaken and the mercury spilled out into a compartment. A shock from the southeast would spill the mercury into the northwest compartment. The earliest self-registering seismograph was simply a vertical pendulum with a flexible marker on the bottom, which made a mark when it was shaken by an earthquake on a flat glass plate underneath. The simple vertical pendulum registers only the horizontal movements of the earth.

What is needed is the recording of the vertical movement as well as what corresponds to the north and south and east and west movements. Most of the recent seismometers register horizontal movements. The horizontal pendulum consists of a mast to which a boom or pendulum moving horizontally is attached by a stay from the top of the mast. The boom ends in a steel point which fits in a concave agate on the mast to insure freedom of movement. The other end of the pendulum which vibrates horizontally is provided with a needle or marker which records its movements on a piece of smoked paper moved by clockwork. Sometimes there is a pen on the end which marks on the white paper. In another form the motion of the beam is photographed on paper on a revolving drum moved by clockwork. It is necessary to get the exact time of arrival of the earthquake. In order to do this a clock with an error of not more than two seconds per week is employed.

The Agemennone, Vicentini, and Weichert seismographs consist of single vertical pendulums. The Von Reuber-Ehlert, Milne, and Omori seismographs have horizontal pendulums. There is a seismograph that registers the vertical motion of the earth. The horizontal pendulum seismographs are always used in pairs. One is arranged so as to register the north-south component of the earth motion, the other the east-west component.

Prof. C. F. Marvin, of the Weather Bureau, who has made some ingenious improvements in registering the seismogram or earthquake message, says: "None of the existing seismographs is adapted to register all kinds of earthquake motion. If we wish to record microseismic motions we must get one sort of instrument, a different instrument for the satisfactory registration of large distant disturbances, and a third type of instrument for damaging or destructive shocks. The existing instruments of the first two types, if not completely cracked when subjected to destructive shocks at least are seriously disordered in most cases and their records falsified and interrupted.

" If one sets out to equip a seismological observatory he finds himself obliged to instal a large number of instruments. Not only must these be of different types, adapted to the different degrees of intensity and character of earthquake motion, but in many cases at least two instruments of each type are necessary, since we have two components of horizontal motion to register, and the horizontal pendulum can record only one component of motion."



Milne Horizontal Pendulum Seismograph.

Omori states: " No single seismograph can record clearly all the different sets of vibrations comprising the earthquake motion, when the slow component is of large amplitude. At least two instruments are required for the horizontal or vertical motion."

Prof. Wiechert, in 1907, invented a seismograph that would not only record the far-distant earthquakes of great intensity, but also the local earthquakes.

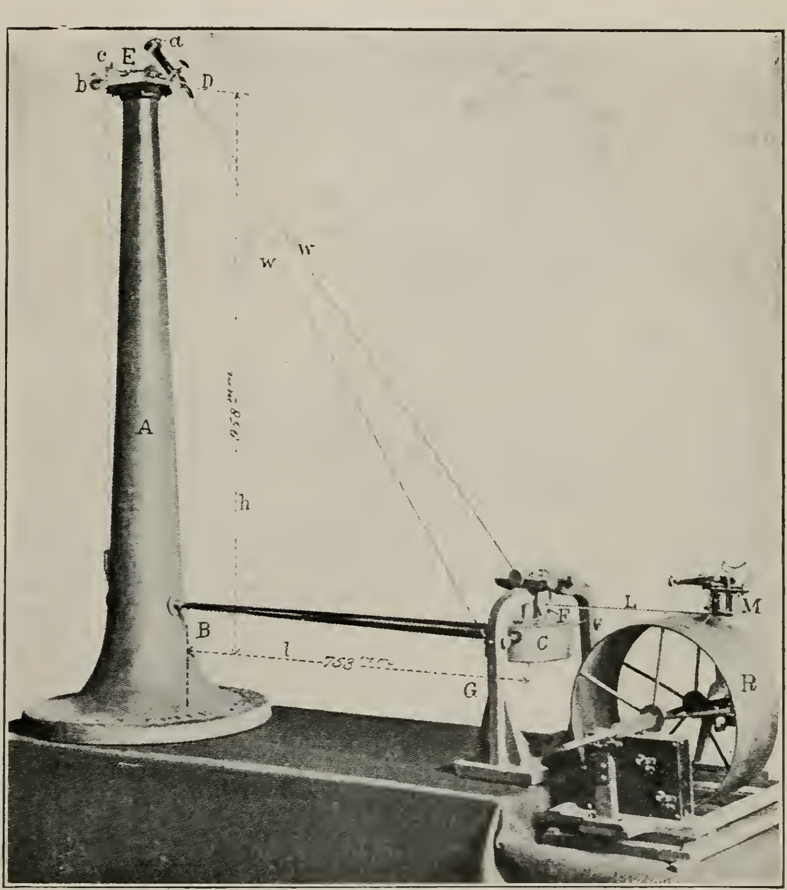
Prof. Milne's seismograph of the horizontal pendulum type is readily understood from the accompanying diagram. The mast is 50 c.m. high, the boom is 120 c.m., or about four feet long. A wire stay or tie from the masthead supports the boom. The other end of the stay is fastened to the stand. A small weight keeps the boom taut. A knife edge or steel point projects from the bottom of the mast and fits into an agate cup at the end of the boom. This insures freedom of motion for the boom so that it can vibrate horizontally whenever disturbed by an earthquake. An inclined mirror reflects the light from a lamp. The end of the boom has a thin piece of metal with a hole or slit. Underneath the mirror is a box containing a roll of photographic paper driven by a clock. In the top of the box is a small slit directly under the slit in the boom. A beam of light reflected by the mirror through the two slits makes a point on the paper. When the boom is disturbed by an earthquake it vibrates horizontally and traces a sinuous line on the photographic paper.

The following illustrations of a Bosch-Omori horizontal pendulum seismograph at the Weather Bureau are taken, together with his description, from an article on the Omori Seismograph at the Weather Bureau, by C. F. Marvin, Professor of Meteorology.

THE WEATHER BUREAU SEISMOGRAPH.

" The instrument as set up to photograph is shown in Fig. 1. As actually installed in a small basement room of the Weather Bureau, the separate castings are secured to thick blocks of stone cemented firmly into the concrete floor of the building and projecting but a few inches above the floor level. The heavy casting *A* forms the support for the so-called horizontal pendulum *B C D*. *C* is a massive lead weight, rigidly attached to the conical tubular rod *B*, the end of which, at *B*, terminates in a hardened steel plug, hollowed out cup-wise and highly polished. At this point the pendulum is supported upon a sharp, conical pointed stud of hardened steel fixed to the casting *A*. The remaining support for the pendulum consists of a pair of steel wires, faintly seen at *w w* in the picture. At the weight end these are attached to eyes with a knife-formed inside edge and there engage two studs that project laterally from the mass *C*. At *D* the wires are united to a stirrup, which at the point opposite the wires is provided with a bit of hardened steel formed with a cut-shaped recess and highly polished. Here the stirrup is supported on a sharp, hardened steel cone attached to the carrier *E* forming the summit of the casting *A*. The carrier *E* is provided with several adjusting screws; thus, *a* serves to raise or lower the weight *C* and thus adjust it to a horizontal position, while *b* causes the point at *D* to move away from or near to the top of the column, and, finally, a pair of screws, one of which is seen at *c*, gives *D* a lateral motion in the horizontal plane. In short, the pendulum *B C D* is supported at *B* and *D* on sharp steel points

FIG. 1.



Bosch-Omori horizontal pendulum seismograph at the Weather Bureau. From originals furnished by the U. S. Weather Bureau.

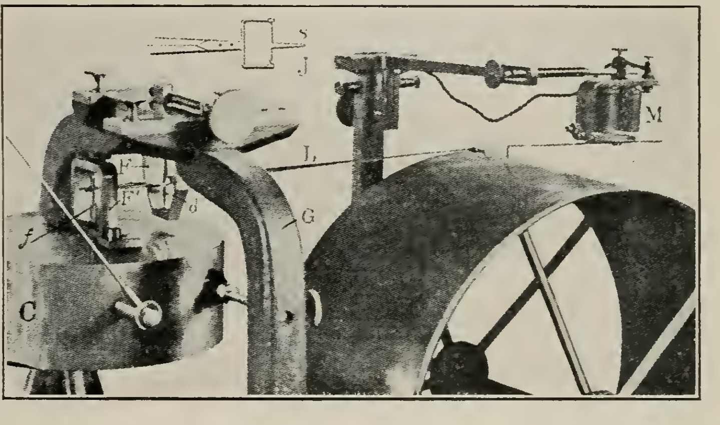
and swings therefore with great freedom of motion. If the points *B* and *D* are rigorously in a vertical line, the pendulum is in neutral equilibrium and the mass *C* will then remain at rest in any position. For practical work, however, a small degree of stability must be imparted to the mass *C*, otherwise minute changes of temperature and other influences which it is impossible to control will cause the mass *C* to wander about from one position of rest to another. The desired degree of stability is given to the pendulum by means of the screw *b* and the azimuth of the point of rest is adjusted by the screws *c*. The degree of stability is determined by noting the time of vibration of the mass *C*, which can be adjusted to swing as slowly as one complete vibration in thirty or forty seconds. A period of twenty-five to thirty seconds seems to contribute a sufficient stability for practical work.

The whole object sought in this construction is to secure a "steady mass," as it is called; that is, a mass that shall remain quite at rest during an earthquake, notwithstanding that the earth and the supports for the mass are undergoing appreciable vibratory displacements. The kinetic property of bodies utilized in this connection is that which gives rise to the so-called *axis of instantaneous rotation*. Whenever any force is applied in a one-sided fashion to move a body all points of the body will not move in the same manner, in fact, one point, or a line of points, will actually remain sensibly at rest for small displacements. This point, in mechanics, is called the *axis of instantaneous rotation*, or *the centre of percussion*.

In the case of the pendulum *B C D* nearly all the mass is concentrated at *C* and the result is that the axis of instantaneous rotation, or, as we shall call it, the steady line, is at a point very near the centre of the mass *C*. Consequently whenever the support *A* is displaced horizontally with a vibratory motion, as in the case of an earthquake, the steady line of the mass *C* will remain at rest for all movements transverse to the plane *B C D*. Motion directly in the line of the strut is communicated, of course, to *C*, but the registering mechanism is so disposed that such motions produce no record whatever. Although the mass *C* is very largely displaced whenever the support *A* is tilted even in the slightest degree in a direction perpendicular to the plane *B C D*, results have nevertheless shown that tilting is not an appreciable feature in earthquake motion, except near the origin of the disturbance, or possibly in the case of large waves. We find then that the steady line of the mass *C* remains relatively stationary during an earthquake disturbance, and the manner of recording the movement of the earth with respect to this point is shown more in detail in Fig. 2.

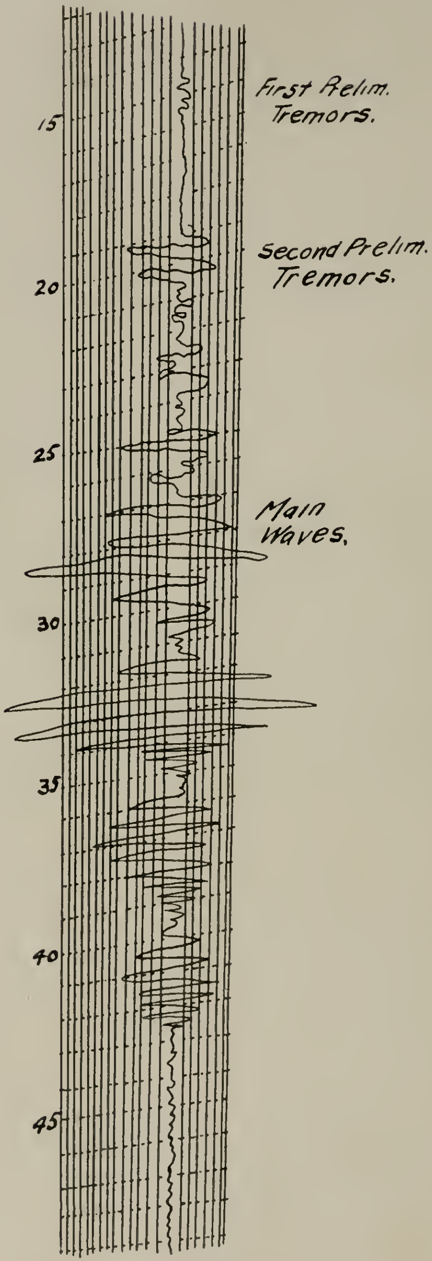
The magnifying and recording lever shown at *L* is made of very thin sheet aluminum bent into an inverted trough-shaped section to secure stiffness, and is provided with a conical pointed, hardened steel, axis, *d*, which is centred and carried in the stirrup *F* which, in turn, is adjustably but firmly attached to the heavy casting *C*. The short arm of the lever *L* is slotted and engages the slender staff *f* in the manner shown. The staff *f* is made of hardened steel, with conical pivot points centred in the stirrup *F′*, which is securely attached to the mass *C* in such a position that the centre of the staff *f* lies in the prolongation of the steady line of the mass *C*.

FIG. 2.



Recording and time-marking devices; original form. From originals furnished by the U. S. Weather Bureau.

The record is traced on a sheet of smoked paper wrapped around the large cylinder *R*, Fig. 1. In order that the friction may be reduced as far as practicable at the tracing point, the coating of soot is made relatively thin and a paper with a highly glazed surface is employed. Much depends also upon the tracing point which is a mere bit of steel, *s*, pivoted to the lever in the manner shown at *J*. The degree of magnification can be adjusted to suit by shifting the carrier or stirrup *F* so as to increase or



Record of a distant earthquake.

shorten the distance between the staff *f* and the pivot *d*. Provision is made for a magnification of from 5 to 15 times. A 10-fold magnification seems to give about the best results for feeble earthquakes.

DOES THE ATTRACTION OF THE SUN AND MOON MAKE A TIDE IN THE CRUST OF THE EARTH AS WELL AS IN THE OCEAN?

According to Lord Kelvin's calculation the combined pull of the sun and moon is such an enormous attractive force that it would cause a globe of steel to yield like India rubber. Astronomers have been wondering for many years whether this double attraction was not sufficient to cause a tide in the crust. The general opinion seemed to be that the crust was too rigid.

As early as 1837 Antoine d'Abbadie made a series of experiments with spirit levels to ascertain deviations from the vertical. He failed to establish anything. In 1878 Lord Kelvin tried. He used a long pendulum and a small galvanometer mirror. Twenty-five years ago Sir George Darwin and his brother Horace made an effort to measure the rise and fall of a certain point on the earth's surface under the attraction of the moon. All of these experiments failed to prove that there was a crustal tide.

It now seems as if patient efforts were crowned with success. It is alleged that Prof. Hecker, of the Prussian Geodetical Institute, has been experimenting for more than four years to prove there is a tide in the crust. Sir George Darwin is made to say in a special cablegram that " Dr. Hecker's apparatus is in a chamber cut out of the side of a wall 80 feet below the earth's surface, and he has continued to make observations by means of photography day and night for six years. It is from these observations that it is possible to determine how stiff the earth is. It is just about as stiff as if made from steel. If it were made from steel it would move up and down one-third as much as if liquid throughout."

Dr. Hecker's alleged explanation is: " When a ship mounts the crest of a wave the masts lean backward and a plummet hanging from the top of the mast will always swing from the base. Likewise if you suspend a plummet from a peak or column standing firmly on the surface of the earth, the plummet will oscillate as a tidal wave rolls along the land. If we use Von Rebeur's horizontal pendulum we are capable of recording oscillations up to a one twenty-five thousandth of an inch."

It is said that the land rises and falls between 7 and 8 inches twice a day. Flammarion states that "Prof. Hecker's experiments were made 80 feet below the ground by an apparatus of extreme precision made of two horizontal pendulums and that the deviations that had to be measured did not as a rule exceed one hundredth of a second of an arc. At the extremity of a pendulum one meter in length they produce movements which measure only a few hundred thousandths of a millimeter. In other words, they are imperceptible. How could one amplify them to make them visible? By the mode of suspension of the pendulum, by mirrors reflecting in the distance one luminous point and recording photographically the image on a cylinder. It is thus that waves are recorded twice a day like those of the ocean tides. These waves have been examined hour by hour and eventually those were recognized which were due to solar attraction and those caused by lunar attraction."

The writer knows that about 10 years ago Prof. Milne stated that no instruments have as yet revealed a tide in the crust, but that delicate instruments would some day show that there was a land wave of about one inch in 300 miles, but that it would be insignificant compared to earthquake pulsations.

This discovery that the earth's crust yields to the attractive force of the sun and moon and is actually lifted a couple of inches is of great interest and importance in the study of seismology. It may be a determining factor in the production of earthquakes, not necessarily the cause, but it may determine sometimes the time of an earthquake. For example, suppose the strata are subjected to enormous stress and tension and are about to break and form a fault, or suppose the fault already formed and the wall even recemented in the past, and then, owing to enormous stress or strain, the walls are about to part and slide either vertically or horizontally. The combined pull of the sun and moon may determine the time when it will occur, that is, when the strata will break or when the walls of the fissure will slide. It does not produce the earthquake, but determines the time it takes place.

As Le Conte aptly said years ago, it is the last straw that breaks the camel's back. If we are ever able to predict earthquakes with any degree of certainty, which is extremely doubtful; this recent discovery will be a prime factor in solving the problem.

Wm: H. Wahl

FRANKLIN INSTITUTE

WILLIAM HENRY WAHL, Ph.D.

1848–1909.

The records of the Franklin Institute during the past thirty years epitomize the history of a period during which the arts have seemed to outrun the sciences in an onrush of advancement. The records reflect the annals of a generation during which these advances have opened the way to possibilities undreamed of heretofore. In the promotion of this great movement, the Franklin Institute, early established for that very purpose, has largely performed its part, and among the men who have had the largest share in that performance, and the one upon whom was devolved, through almost the entire period of a generation, its most immediate function, was the late Secretary of the Institute, Doctor William Henry Wahl.

Fitted for the varied duties of his office not alone by native ability and a liberal education, but even more signally by a most congenial temperament, Dr. Wahl was held to the secretaryship of the Institute by annual re-election, first for a period of four years and thereafter continuously through more than a quarter of a century; he thus became, through normal sequence, the actual leader in the Institute's activities. To those activities he devoted himself with never-ceasing earnestness, and to no one is due a larger measure of credit for the maintenance and advancement of the Institute's reputation as a focus of the applied sciences than to its widely reputed Secretary.

William H. Wahl was born December 14, 1848, in Philadelphia, and became a pupil of its public schools. In 1863, while yet but fifteen years of age, he was admitted to Dickinson College, whence he was graduated with a bachelor's degree in 1867. Following his bent for the physical sciences, he proceeded to the University of Heidelberg, then made famous as the centre of instruction in those branches of knowledge by such leaders in science as Bunsen, Kirchhoff and other masters of lesser note.

There his diligence and proficiency gained him in 1869, after two years of study, the degree of Ph.D. During a vacation visit to his home at this time he became acquainted with Professor Morton, then Secretary of the Institute, who, finding occasion to engage the services of Dr. Wahl in an editorial capacity, was thereby led to obtain from him a series of contributions to the journal of the Institute on the subject of crystallography, of which Dr. Wahl had made a special study in original researches. When, in the following year, 1870, Professor Morton retired from the secretaryship of the Institute, he recommended Dr. Wahl as being a most competent successor; the latter was thereupon elected to the position, continuing to hold it through four years, until the close of 1874. At this time he collaborated with Prof. Spencer F. Baird, of the Smithsonian Institution, in compiling the "Annual Record of Science and Industry," published by the Harpers' in the years 1874 to 1878.

During this period Dr. Wahl supplemented his work at the Institute with services, from 1871 to 1873, as Instructor in the Physical Sciences at the Philadelphia Episcopal Academy, and in 1875–1876 as Professor of Physics and Physical Geography at the Central High School. From 1873 to 1876 he was editor of the Department of Arts, Sciences and Patents of the *American Exchange and Review.* His abilities as a scientific journalist became widely recognized, and led to his becoming editor of the *Polytechnic Review,* Philadelphia, from 1876 to 1879; associate editor of the *Engineering and Mining Journal,* New York, from 1878 to 1881, an editor of the *Manufacturer and Builder,* New York, from 1880 to 1896. But it was as editor of the Journal of the Franklin Institute, a service incident to his function as Secretary, that Dr. Wahl performed his principal work in an editorial capacity, and the upbuilding of the journal from the status of a reprint of current scientific data to that of a source of original information on these subjects, has been primarily and almost solely due to the energetic efforts of Dr. Wahl.

In addition to his activity in these various directions, there may be cited as part of a long list of his contributions to the scientific literature of his time: viz., his book on "Galvanoplastic Manipulation," published in 1883; the "Techno-Chemical Receipt Book" (in collaboration), 1885; the "Hand-Book of Assaying," a translation from the German with addition of original matter; "Constructive Arts," a synthetic treatise, in large octavo form, profusely illustrated and forming vol. v of the "Iconographic Encyclopædia, 1894;" a "Report on Petroleums, as to their Safety and Danger," for the National Board of Underwriters, New York; a valuable study on "Wasted Forces," for the *Popular Science Monthly*, 1875; "A new method for the Preparation of Metallic Manganese," and an article on the "Preparation of Metallic Alloys," both printed in the JOURNAL OF THE FRANKLIN INSTITUTE in 1893. These papers are descriptive of his investigations and development, in collaboration, of two important metallurgical processes, one for the reduction of refractory metallic oxides by means of aluminum and the other for the reduction of such oxides by means of silicon. These published investigations anticipate by several years the subsequent commercial development of the art, and are now being increasingly utilized in the steel making industry where low carbon ferro alloys are required. Wahl's process of reducing metallic oxides is similar in principle to a method of reduction which has latterly come largely into practical use, in which the oxide is mixed with powdered or granulated aluminum and ignited in a cold crucible, resulting in the reduction of the oxide and the production of a very high temperature for purposes of welding.

Among the various important services rendered to the Institute by Dr. Wahl apart from his immediate function as its Secretary, was his organization of the several individual sections of the Institute in the various branches of the applied sciences. Under his fostering influence these sections have become a principal feature of the Institute's activity. Their proceedings have largely supplemented those of the Institute in general and have enriched its journal with many records of original scientific research.

Still another, and by no means the least important of Dr. Wahl's services as organizer and leader, was his work in connection with the Institute's Committee on Science and the Arts. As ex-officio Secretary of that committee, he devoted his efforts with characteristic energy and zeal to the enlargement of its activities, and it is not too much to say that the great development of the work of the Science and Arts Committee which has taken place during the past twenty-five years, has been principally due throughout all that time to the unremitting efforts of the

Secretary, given to that end. His work in this connection would alone have sufficed to engross the labors of a less diligent hand.

Yet other of Dr. Wahl's activities in the various directions of the Institute's work remain to be recorded here. As ex-officio Secretary of the Committee on Library, his wide and thorough acquaintance with the literature of the applied sciences was a never-failing source of inspiration and guidance to that important commission of the Institute, and there, as in his other functions, he performed his part most acceptably. So too, as member of the Committee on Instruction, in which capacity, as a principal director of the Institute's school and as the immediate coadjutor of the professors and instructors, he performed a service of lasting benefit to the cause of technical education. In short, in each and all of the various functions which devolved on Dr. Wahl, partly from the nature of his position as Secretary but largely also through a readiness as willing as his abilities were thorough, he performed his part in a manner that constantly elicited the approval and frequently the admiration of his colleagues. Various honors in recognition of Dr. Wahl's accomplishments in the domain of the applied sciences came to him from time to time from various sources, but owing to his extreme reserve in relation to such matters, no definite reference to these distinctions appears in the records of the Institute. It is known, however, that some years ago, he was accorded the honor of appointment as Officer d'Instruction Publique by the French Government, in recognition of services rendered by him in a special scientific investigation.

The versatility of Dr. Wahl's talents was no more remarkable than was the peculiar combination of widely varying traits in his personality. In that respect he presented a rare example of a notably dignified presence marked by an engaging geniality —a man of impressive poise and of never-failing urbanity. He was a scholar of wide-embracing acquirements, a person of strong convictions and of liberal open-mindedness. His personality became, indeed, a veritable part of the Institute, for which, to the very end, he manifested a deep and ever watchful solicitude.

That this solicitude extended beyond his life, he evidenced in his will. Therein he provided that his entire estate (estimated to amount to about $75,000.00) be held in trust for use and benefit of his widow during her life, and that thereafter it be held for the use and benefit of the Franklin Institute, as a memorial to his father, John H. Wahl, provided, indeed, that within three years after its reversion, an equal sum be contributed from other sources, not including bequests. Even this provision affords proof of Dr. Wahl's care for the welfare of the Institute, the provision of three years for the obtainment of the additional contribution being doubtless ample for the far-sighted purpose of the testator.

Dr. Wahl was married at an early age to Julia Lowther, a member of a prominent and cultured family of County Mayo. Ireland, but neither of his two children survived their infancy. His wife was long an invalid, and died a number of years ago. Some years later he married her sister, Mary B. Lowther, who has survived to mourn the loss of one who, having been a life-long friend, became her devoted husband.

The solicitude for all the varied interests of the Franklin Institute manifested by Dr. Wahl in all his relations to it, seemed even to increase as his activities became gradually curtailed through failing health. In the winter of 1906–1907, he suffered a collapse of the nervous system from which he never fully recovered. Several voyages to the Caribbean islands helped to so far restore his vigor as to enable him to continue at his post through the following year, but the summer of 1908, spent at his country seat at New Britain, near Doylestown, Pa., brought him to the point of resigning his position. His resignation was declined by the Board of Managers in the hope that his shattered health might yet become restored, but the ensuing winter season of the Institute was opened for the first time since 1882 without Dr. Wahl's inspiring presence. His resignation, again urged by him at this time was, on January 13, 1909, reluctantly accepted by the Board, which thereupon adopted the following resolution:

> *Resolved,* That the resignation of Dr. William H. Wahl as Secretary of the Franklin Institute, having brought a termination to the faithful and unremitting service which he has rendered in that capacity through more than a quarter century past, the Board of Managers of the Institute enters upon its minutes this acknowledgment of Dr. Wahl's successful efforts in the furtherance of the Institute's work and this expression of regret that the condition of his health has appeared to necessitate at least a temporary cessation from his labors.
>
> In the organization of the scientific sections of the Institute, in the promotion of its lecture courses, in the enlargement of its schools, and in the editorial direction of its Journal and other publications. Dr. Wahl has performed a distinguished part in the activities of the Franklin Institute, and left a lasting impress on its history.

As a mark of appreciation of Dr. Wahl's services as Secretary and as a member of this Board, this minute is ordered to be suitably engrossed for presentation to Dr. Wahl and to be published in the Journal of the Franklin Institute.

At the meeting of the Institute on February 17, following, on recommendation by the Board, Dr. Wahl was unanimously elected Honorary Secretary of the Institute. A record of this action was ordered to be engrossed, along with the resolutions of the Board, in a testimonial album for presentation to the Honorary Secretary. This album had but barely reached its destination when, on March 23, 1909, its recipient passed away.

With a quotation of the minute adopted by the Committee on Science and the Arts on March 24, 1909, this memoir of an earnest and able helper in the doing of the world's work may fittingly be closed:

The Committee on Science and the Arts of the Franklin Institute has learned with deep regret of the death on yesterday of the Honorary Secretary of the Institute, DR. WILLIAM H. WAHL. As ex-officio Secretary of this Committee throughout more than a quarter of a century of unremitting service, Dr. Wahl's earnest co-operation in all the various directions of this Committee's work has been a most potent influence in promoting its aims and purposes, and his associates on this Committee herewith record their sense of the great loss which the Committee on Science and the Arts has sustained through his demise.

LOUIS E. LEVY, Chairman }
CHAS. E. RONALDSON, } Committee.
WASHINGTON JONES, }

FRANKLIN INSTITUTE

(*Proceedings of the stated meeting held Wednesday, May 19, 1909.*)

HALL OF THE FRANKLIN INSTITUTE,

PHILADELPHIA, May 19, 1909.

DR. E. GOLDSMITH, *Temporary Chairman.*

Present, sixty members and visitors.

Addition to membership since last report, 10.

The Chairman called for nominations for Trustee of the Elliott Cresson Medal Fund, to fill the vacancy caused by the death of Dr. William H. Wahl. Mr. Walton Forstall nominated Mr. E. H. Sanborn, and as there were no further nominations the Secretary was directed to cast the ballot for the meeting.

The paper of the evening on the "Present Aspects of the Panama Canal from the Tourist's Point of View" was then read by Mr. William Tatham, of Philadelphia.

The speaker reviewed the early attempts at building an interoceanic canal and gave a brief account of the work accomplished during the past few months. Attention was given to the dams and locks, to the methods of excavating and removing the earth, and to the housing and feeding of the many employes. Lantern photographs of views along the canal and scenes from Panama, Ancon, and other towns were shown. A vote of thanks was tendered the speaker for his interesting paper.

Mr. A. C. Lippincott, of the Lippincott Steam Specialty and Supply Company of Newark, N. J., then exhibited and described some new stoves, lamps, and pressing irons for denatured alcohol.

On motion the subject was referred to the Committee on Science and the Arts for investigation and report. Adjourned.

JAMES CHRISTIE,
Secretary.

COMMITTEE ON SCIENCE AND THE ARTS.

(Abstract from proceedings of the stated meeting held Wednesday, May 5, 1909.)

HALL OF THE FRANKLIN INSTITUTE,

PHILADELPHIA, May 5, 1909.

MR. J. Y. McCONNELL in the Chair.

The following report was presented for final action:

(No. 2449.) Emergency Exit Door Lock.—Hugh Elmer Clark, Rochester, New York. (An advisory Report.)

The following reports passed first reading:

(No. 2432.) Color Photography.—Lumière & Son.

(No. 2441.) Primary Battery.—Charles E. Hite. (An advisory Report.)

(No. 2450.) Boring and Reaming Tool.—Benjamin Brownstein, Trenton, N. J.

(No. 2457.) Telelectric Piano Player.—John F. Kelly, T. D. Powers, and M. R. Jewell.

(No. 2460.) Trigonometric Slide Rule.—M. J. Eichhorn. (An advisory Report.)

BOOK NOTICES

Les Planetes et Leur Origine par Ch. Andre, Directeur de l'Observatoire de Lyon, vi + 285 pages, 6 × 9 inches with 94 illustrations and 3 plates, 1909; price, 10 francs. Paris. Gauthier-Villars.

The object of this work is to outline the progress of astronomical knowledge from the end of the 18th century to the present time, and is divided into three main divisions—planets, satellites and the formations of planetary systems. Under the separate titles of planets named, the investigations made and the apparatus employed are described and the names of observers given.

Particular attention has been given to the motions of Venus and Mercury and to the configuration of Mars.

The subject is well illustrated, conveniently subdivided and, as in most French publications, a full table of contents is given in lieu of an index.

L. E. P.

Heat Energy and Fuels: Pyrometry, combustion, analysis of fuels and manufactures of charcoal, coke and fuel gases. By Hanns v. Juptner, Professor, Imperial and Royal Technical Institute, Vienna. Translated by Oskar Nagel, Ph.D., v + 306 pages, 118 illustrations and many tables. Price, $3.00 net. New York, McGraw Publishing Co.

The subject of heat energy, methods for its production and a consideration of the available fuels, is of the deepest interest to the technologist in any branch of industry. The appearance of a work treating the subject in a logical and comprehensive manner, containing the results of the latest researches, cannot fail to find an extended field of utility. Following the introductory chapters containing a general discussion of forms of energy and their thermodynamic relationships, the subject is classified under the divisions pyrometry, the cost of combustion and its determination, and fuels. The work abounds with tables and data, and the descriptive matter is well illustrated by cuts and diagrams. The topics included are discussed in a thorough and practical manner and deductions are consistently carried out in accordance with the principles reviewed in the preliminary chapter.

The book is of a grade that should place it among the standard works on engineering practice.

L. E. P.

Les Oscillations Electromagnétiques et la Télégraphie Sans Fil par le Professeur Dr. J. Zenneck. Ouvrage Traduit de l'Allemand par P. Blanchin, G. Guerard, E. Picot, Officiers de Marine. Deux volumes in 8 (25–16) se vendant separement. Tome I: Les oscillations industrielles. Les oscillateurs fermés à haute fréquence. Volume de xii + 505 pages, avec 422 figures: 1909. 17 fr. Tome II: Les oscillateurs ouverts et les systèmes couples, les ondes électromagnétiques et la télégraphie sans fil. Volume de vi + 489 pages, avec 380 figures; 1909. 17 fr.

This work is based upon a series of lectures delivered by the author at the University of Strasburg during the period from 1901 to 1903 and intended principally for students of technology with limited mathematical training. The development of the subject has, accordingly, proceeded more by reference to physical and geometrical relationships than by analytical methods, and when a complete exposition of a principle has required an application of higher mathematics, it has been treated in the notes at the end of the volume.

The first volume relates to the production of oscillating currents, beginning with the fundamentals on electromagnetic induction and developing the subject over the field usually covered in works on alternating currents, leading to consideration of high frequency oscillations required in wireless telegraphy apparatus.

The second volume is a continuation of the last chapters of the first and proceeds with the development of the methods of producing electromagnetic waves and the apparatus applicable to wireless telegraphy installations.

With the numerous commercial applications of wireless apparatus the necessity of a close study of the subject is apparent, and a work covering the field from fundamentals to commercial apparatus should have an extended sphere of usefulness.

L. E. P.

MACHINE—OUTILS. OUTILLAGE—VERIFICATEURS. Notions Pratiques par P. Gorgeu, Capitaine d'artillerie. iv + 232 pages, 6½ x 10 inches, with 200 diagrams, 1909; price 7 f. 50. Paris, Gauthier-Villars.

The present work is intended chiefly for the guidance of artillery officers engaged in inspection service. The operation, the relation of the different parts, and methods of driving of the usual types of machine tools, wood-working tools, and measuring devices are illustrated and described.

The subject is presented under four main divisions:

Part 1. Generalities on machine tools—relates to the kinematic devices employed.

Part 2. Study of classified groups of machine tools—considers the various tools embraced under the respective operations of cutting, shearing, grinding, hammering, die-pressing, and drawing.

Part 3. Cutting tools—relates to the principles involved and the manufacture of cutting tools.

Part 4. Construction and use of test-gauging instruments—describes the different forms of test-gauges employed in machine construction, methods of using, tolerances, and other matters involved in the process of inspection.

The illustrations are of the diagrammatic type only and do not purport to represent actual machines. The framing is shown in a shaded outline, the moving parts and their relation to each other being clearly defined and easily traceable, a mode of illustration excellently adapted to the intended purpose.

The powerful multi-speed drives and feed mechanisms of lathes employed particularly in ordnance manufacture are not illustrated. Indeed, the work covers a field embracing the elements of modern machine-shop equipment rather than a consideration of the elaborate mechanisms found in the most modern development of high-powered tools.

For a class of readers interested in the elemental operation of machine tools, the subject is well covered. L. E. P.

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